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POWER

Volume 35, No. 25.
Issued Every Tuesday.
Hill Publishing Company.

NEW YORK, JUNE 18, 1912.

Price, 5 cents.
Outline of Topics, 54.
Index to Advertisers, 43.

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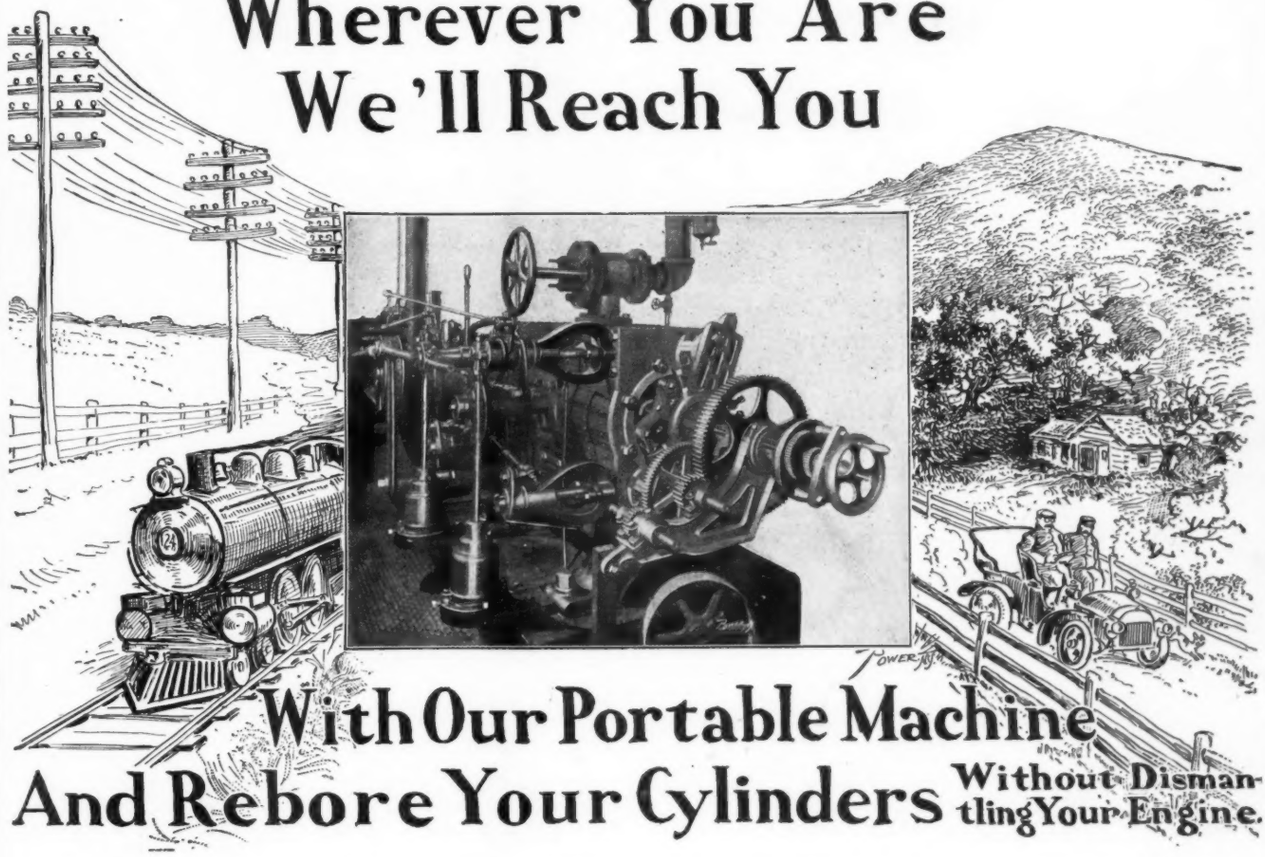

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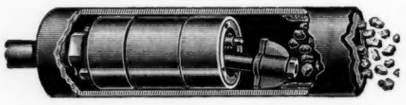

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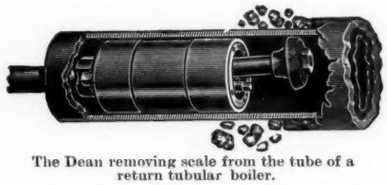

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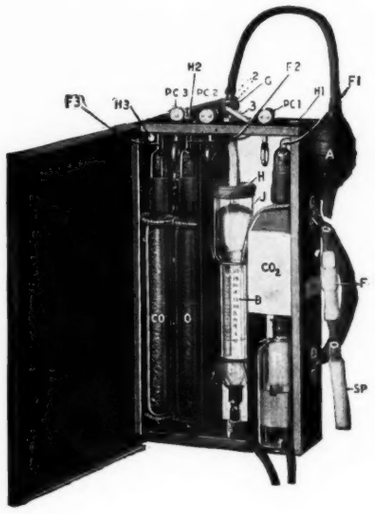

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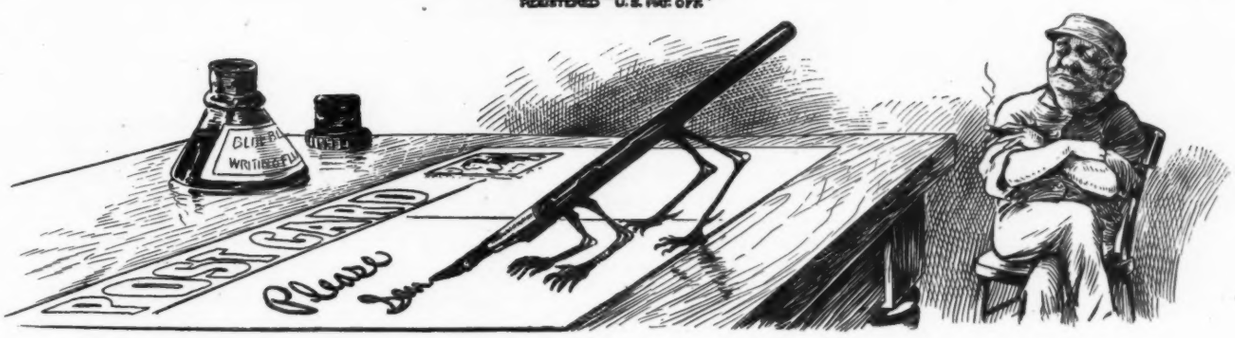

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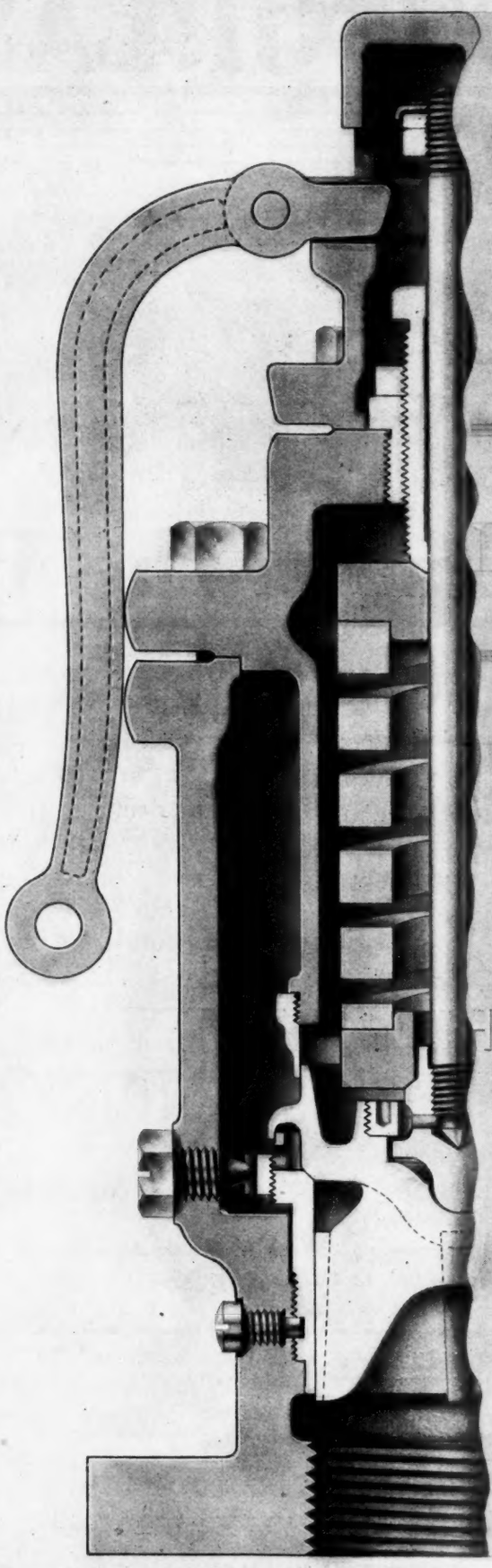

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of a safety valve is to RELIEVE AN EXCESS OF PRESSURE, BUT NO MORE, and one that does relieve more is wasteful and expensive.

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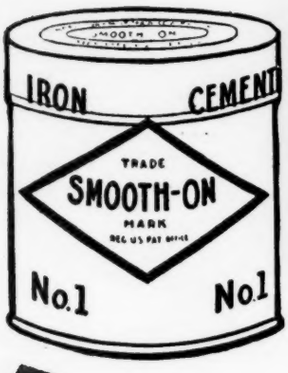

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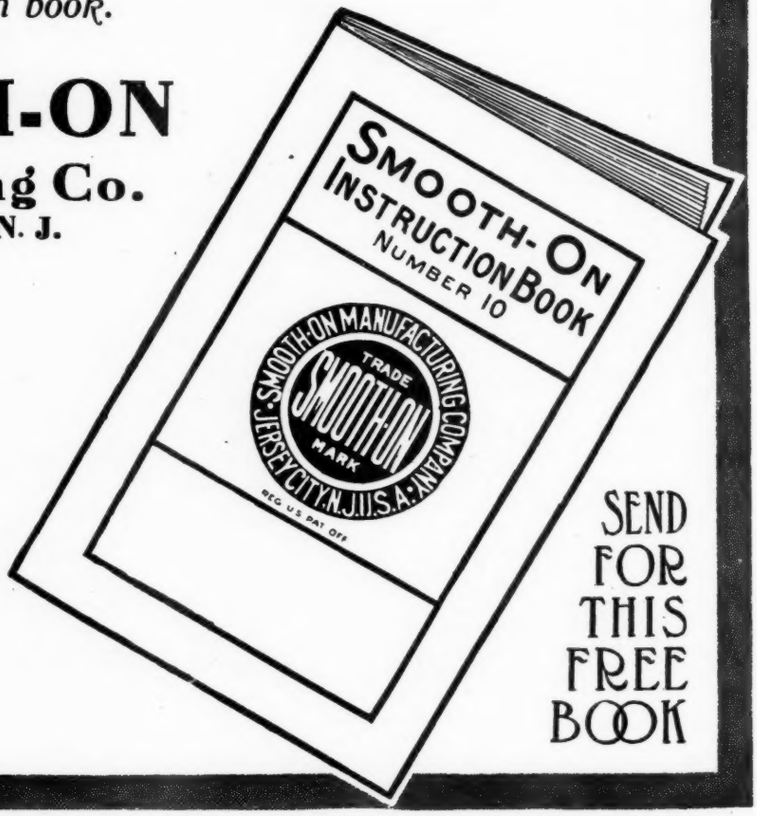

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POWER

Vol. 35 NEW YORK, JUNE 18, 1912 No. 25

The Helpful Paper

WHEN a large engine is to be turned by hand, the engine room force concentrate their efforts in one direction. Were they to pull against one another from opposite sides of the flywheel, nothing would be accomplished. This is typical of any purpose; if there is to be any good done, there must be harmony of effort.

"Power" is devoted to the generation and transmission of power, especially the practical and operating considerations, and its aim is to assist the owner, the manager and the engineer. Its success is dependent in great measure on the hearty co-operation of its more than 30,000 readers acting through the editorial staff. It's like turning the engine over: **A long pull, a strong pull and a pull all together.**

Sometimes a well intentioned member wants to pull the other way without due consideration for his colleagues. He wants the paper to embrace deeper and more technical subjects while another implores that such matter be tabooed. If either had his entire way it would result in an unbalanced load, so to speak, so the editors have to act as the equalizer.

The operating engineer wants material telling him how to run his plant properly without going into mathematics or dealing with things with which he is unfamiliar. He wants plain practical matter readily applicable to his needs. He gets it, and he's going to continue to get it.

Still, the man who wants more advanced information must not be forgotten. It is "Power's" function to cover the whole field of power generation and transmission. There are abstruse problems in which the advanced thinkers in the field are interested. The rate of progress and the comparative achievement of different plants and apparatus are marked by tests the analysis of which may carry the untaught reader over his head. He should not begrudge the space devoted to these subjects, any more than the "highbrow" who can read them should turn up his nose at the more elementary matter. There is more than 4 cents' worth in every issue for every man who will read it.

The phenomenal advance in power plant engineering in recent years has thrown upon the engineer increased duties of a wider and more varied character. To successfully meet the new conditions requires a wider and more varied knowledge. This brings before the engineer many unfamiliar problems and appliances that he is at first apt to consider beyond him. It is "Power's" purpose to tell him about these things, to keep him in touch with the development in his vocation. To shun these important matters would be to cease to be thoroughly practical, to cease to be the leader; hence "Power" must not fail to inform of uptodate practice.

To half tell a thing is worse than not telling it at all. But to tell it all, and tell it in comprehensible language—so you can read it—that is what you want. That is "Power's" plan.

So let us exert an even longer pull, a stronger pull and a pull altogether.

A New Analysis of Indicator Cards

Adapted from a paper by the originator of the analysis, J. Paul Clayton.

Describes means for determining from an indicator diagram an almost complete analysis of the cylinder performance of a reciprocating engine, including results heretofore considered impossible to so obtain accurately.

If when fluid expands, as does steam in the cylinder of an engine, its pressure varies inversely as its volume, the relation of pressures and volumes will be represented by the middle curve in Fig. 1. The product of the volumes and the pressures corresponding with the several volumes will be as follows:

Vol.	×	pressure	= constant
1	×	120	= 120
2	×	60	= 120
3	×	40	= 120
4	×	30	= 120
5	×	24	= 120
6	×	20	= 120

Setting these pressures off upon the corresponding ordinates and connecting the points so located, the curve is formed as shown.

Suppose, however, that the variation of pressure with change of volume were such that the product of the pressure and the *square* of the volume were constant. The pressures for the several volumes would be as follows:

Vol.	Vol.^{2}	× pres.	= constant
1	1	× 120	= 120
2	4	× 30	= 120
3	9	× $13\frac{1}{3}$	= 120
4	16	× $7\frac{1}{2}$	= 120
5	25	× 4.8	= 120
6	36	× $3\frac{1}{3}$	= 120

Setting these values of the pressure off upon the several ordinates, the curve drawn through them is the lower one of Fig. 1.

Suppose, again, that the product of the pressure and the *square root* of the volume were constant, the pressures for the several volumes would be as follows:

Vol.	$\sqrt{\text{Vol.}}$	× pres.	= constant
1	1	× 120	= 120
2	1.414	× 84.85	= 120
3	1.732	× 69.28	= 120
4	2	× 60	= 120
5	2.236	× 53.66	= 120
6	2.449	× 49	= 120

The expression $4^{\frac{3}{2}}$ means that 4 is to be raised to the third power, or cubed, and that the second or square root of that power is to be extracted. Similarly $4^{\frac{1}{2}}$ means that the second or square root of the first power of 4 is to be extracted. As the first power is the quantity itself, this is a convenient way to express the square root of a quantity. The small figure above the number is called the "exponent" and when fractional it may be expressed as well by a decimal as a vulgar fraction thus:

$$\sqrt{4} = 4^{\frac{1}{2}} = 4^{0.5} = 2$$

In Fig. 1 it will be seen that if this exponent is less than unity, the curve will be above the $pv = con.$ curve with which the expansion and compression lines of the steam-engine indicator are commonly compared, while if it is greater than unity, the curve will be below that in plotting which the exponent of v is taken as unity, and a variation of the value of the exponent between 0.5 and 2 will carry the curve from the upper to the lower position in Fig. 1.

J. Paul Clayton, of the engineering-experimental station of the University of Illinois, in a remarkable paper presented at the spring meeting of the American Society of Mechanical Engineers, describes a new method of analyzing the indicator diagram which is full of interest and promise. From the study of a large number of diagrams from engines of various types and running under different conditions, he found that the expansion and compression lines were quite generally true exponential curves, such as would be derived by the formula

$$pv^n = con.$$

but that the value of the exponent n varies between 0.7 and 1.34, the curve ordinarily used being simply the special case where $n = 1$ and $pv = con.$

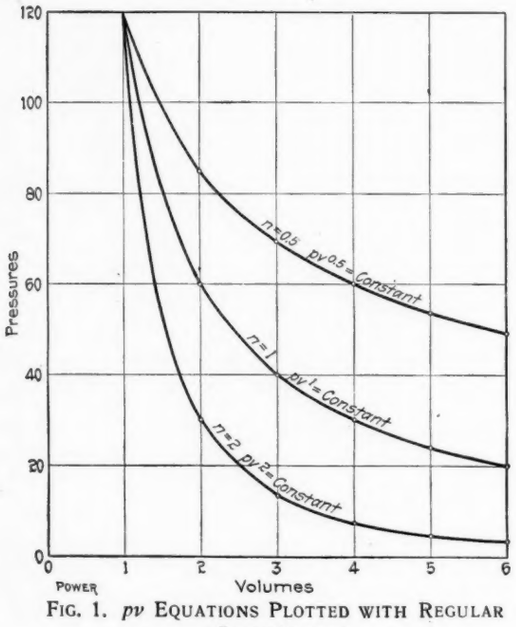


FIG. 1. *pv* EQUATIONS PLOTTED WITH REGULAR CO-ORDINATES

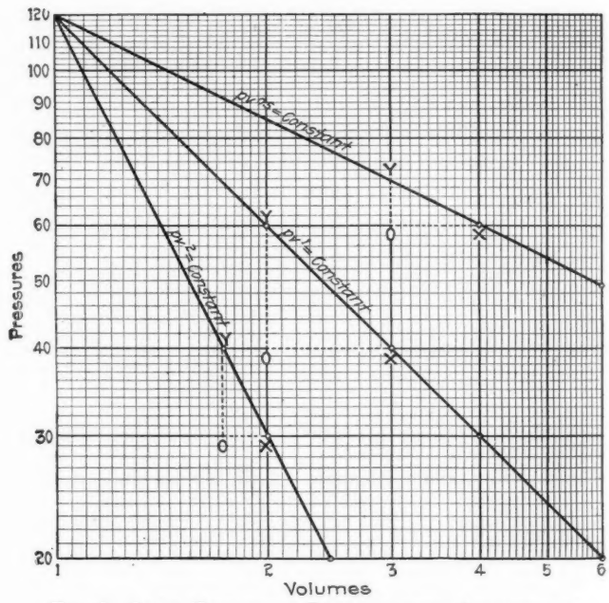


FIG. 2. SAME EQUATIONS PLOTTED WITH LOGARITHMIC CO-ORDINATES

If the ordinates, instead of being spaced equally as in Fig. 1, are spaced like the spaces on a slide-rule, so that the space from 1 to 2 equals the space from 2 to 4 or from 4 to 8, and the heights corresponding to the pressures are laid off in the same way, a curve having the formula

$$pv^n = con.$$

will become a straight line when laid out upon such a field. Paper ruled in this way and called logarithmic cross-section paper can be had from a dealer in draftsman's supplies.

A sample with the curves of Fig. 1 laid out upon it is shown in Fig. 2. The pitch or inclination of the curves (now become straight lines) depends upon their exponent, and the exponent may be de-

termined by drawing a vertical and horizontal line intersecting each other and the curve as in Fig. 2, and dividing the length of the line OX by that of the line OY. Notice that for the middle curve OX is the same as OY and

$$\frac{OX}{OY} = 1$$

On the lower curve OX is only one-half as long as OY and

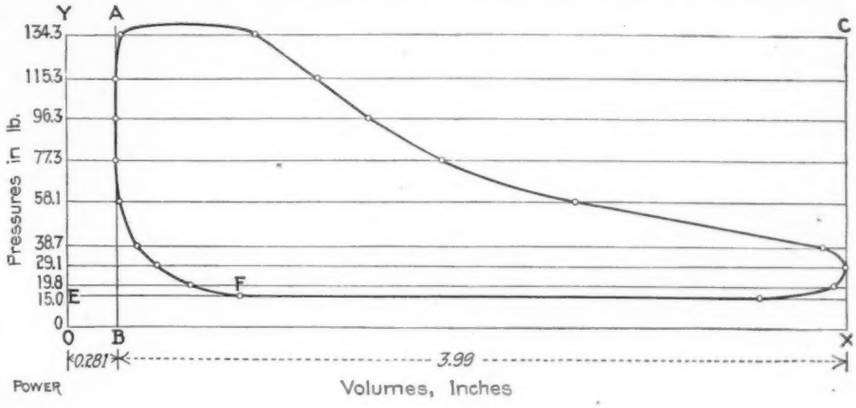
$$\frac{OY}{OX} = 2$$

while for the upper curve OX is twice as long as OY and

$$\frac{OY}{OX} = 0.5$$

indicating thus the exponents used in the formulas by which the curves were laid out.

Mr. Clayton plots not only the expansion and compression curves but the whole diagram upon logarithmic paper, and the diagram so produced offers many important advantages for analysis.



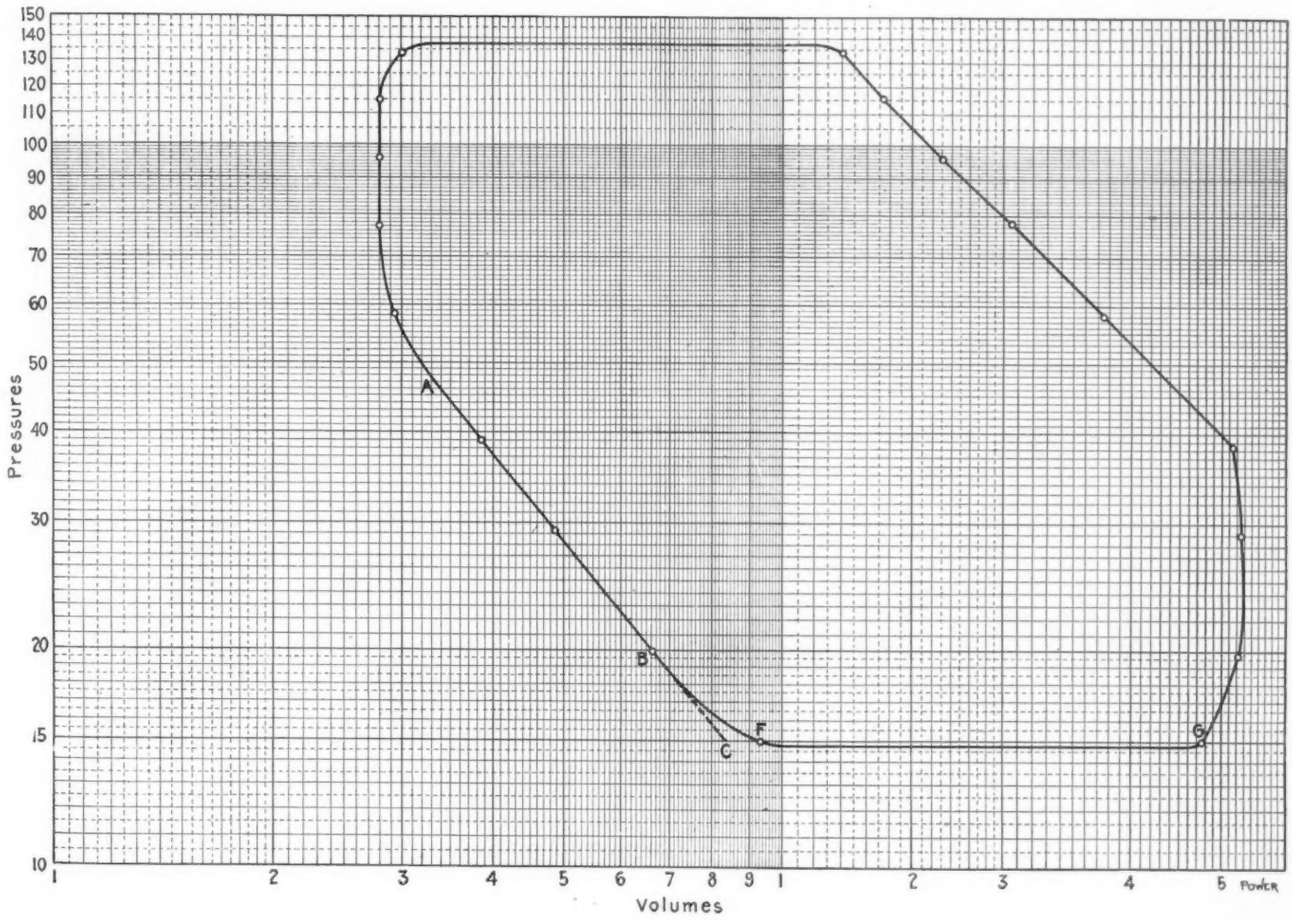


FIG. 3. DIAGRAM FROM CORLISS ENGINE TRANSPOSED TO LOGARITHMIC SCALE

TRANSFERRING THE DIAGRAM

Fig. 3 shows a diagram from a Corliss engine transferred in this way. It must be prepared by putting on the line OX, representing the absolute zero of pressures, and the line OY, representing the absolute zero of volumes. The distance between the line OX and the atmospheric line must be the barometric pressure at the place and time that the diagram was taken measured by the scale of the indicator spring used. The distance between the line OY and the line AB, marking the extreme left of the diagram, must bear the same proportion to the length AC of the diagram that the volume of the clearance bears to the piston displacement. In this engine the clearance is 7.04 per cent. The length AC of the diagram is 3.99 in. The width YA of the clearance space on the diagram is therefore

$$0.0704 \times 3.99 = 0.281 \text{ in.}$$

The barometer reading when the diagram was taken was 14.2 lb. per square inch and the scale of the spring used in the indicator was 79. The distance between the atmospheric and absolute zero lines is therefore

$$14.2 \div 79 = 0.18 \text{ in.}$$

The logarithmic paper used consists of four 5-in. squares arranged two each way, as in Fig. 3, which shows the lower left-hand square complete with portions of the others. As the paper comes from the dealers it is numbered by heavy figures close to the ruling. These have been multiplied by 10 to

give the scale of pressures as indicated by the figures at the left.

The horizontal scale, that of volumes, will do as it is. The printed figures below the lower left-hand square will represent tenths of an inch and the intermediate rulings hundredths, except in the extreme left-hand division, 1 to 2, where there are 20 subdivisions of one-half a hundredth each. The figures in the right-hand square represent even inches.

A number of horizontal lines may be drawn across the diagram, as shown, and their intersections with the diagram transferred to the logarithmic paper. The point *F*, for instance, is at a height corresponding to 15 lb., and its distance *EF* from the zero or clearance line is 0.93 in. The point is thus located on the ordinate 0.93 on the scale of volumes (indicated by *f* on the horizontal scale) at the intersection of the horizontal line indicating 15 lb. At the same height but at the horizontal distance 3.77 is located the point *G*.

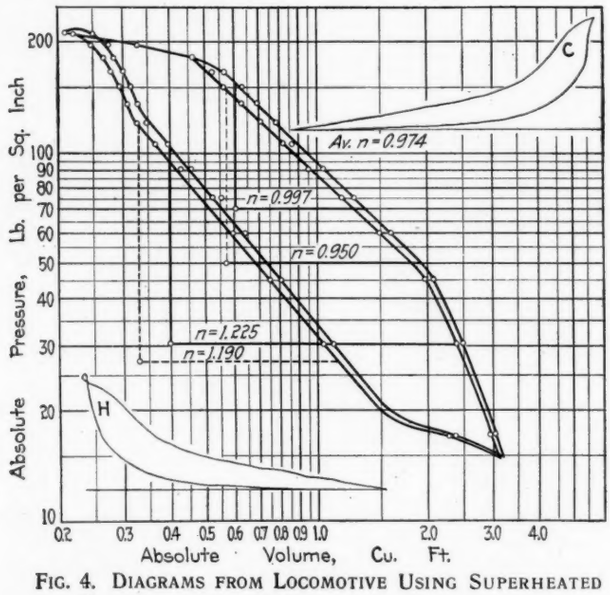


FIG. 4. DIAGRAMS FROM LOCOMOTIVE USING SUPERHEATED STEAM

In this way the several points of the indicator diagram are transferred to the logarithmic paper and lines drawn through them furnish the logarithmic diagram. The values of the pressures and volumes used in the diagram as given by Prof. Clayton are as follows:

Abs. pressure, lb. per sq.in.	Distance from zero volume line of points on	
	Compression line	Expansion line
134.3	0.30	1.205
115.3	0.28	1.39
96.3	0.28	1.65
77.3	0.28	2.06
58.1	0.295	2.76
38.7	0.385	4.12
29.1	0.485	4.26
19.8	0.66	4.29
15.0	0.93	3.77

There is no reason why the spacings should not be located at even pressures, and one wonders how the professor read to tenths of pounds with a 79-lb. scale, but small differences in the pressures would have little effect upon the location of the points, especially in the upper part of the diagram.

LOCATION OF POINTS OF CUTOFF COMPRESSION, ETC.

The point of cutoff can be located on the ordinary indicator diagram to within $\frac{1}{16}$ in., measured on the diagram itself. The actual beginning of true compression, however, can never be accurately located on such a diagram. True compression, unaffected by leakage, begins after the exhaust valve, in closing, has acquired enough seal to prevent leakage. The point of the beginning of true compression is generally at least 5 lb. above the back pressure. The point at which leakage ceases cannot be indicated upon the pressure-volume or ordinary indicator diagram because the curve of true compression and the curve made during the time the valve has insufficient seal are of the same direction of curvature, and are not reverse curves as in the general case of admission and expansion.

The law $pv^n = con.$ will apply only when the weight of fluid operating is constant. The compression or expansion line of the logarithmic diagram does not become straight until this condition has been established.

In Fig. 4 are shown diagrams from a locomotive taken at short cutoff and high speed. In their form as they came from the indicator the points of cutoff release compression and admission are very difficult to locate, but stand out sharply in the logarithmic diagram. Prof. Clayton says that these events, even though obscure in the pressure-volume diagram, may be located to well within about $\frac{1}{16}$ in. on the logarithmic diagram, this length being equivalent to about $\frac{1}{32}$ in. when retransferred to the *pv* diagram itself.

In most of the diagrams given in the paper the horizontal distances are taken as volumes in cubic feet, instead of lengths on the diagram. The author computes the volume of the cylinder for 1-in. length of diagram and multiplies the distance of the points from the line of zero volume by this factor. When the horizontal scale is used as diagram lengths the location of points determined as in the foregoing may be set off directly on the *pv* diagram at the intersection of the same pressure and volume lines, reversing the process by which Fig. 3 was plotted. When the horizontal scale is used for specific volumes, as in Fig. 4 and others from the paper, the reading for volume must be divided by the volume per inch of cylinder to obtain the horizontal distance on the *pv* diagram. The shape of the diagram will be the same whichever value is used for the horizontal scale; it will simply be shifted horizontally on the paper.

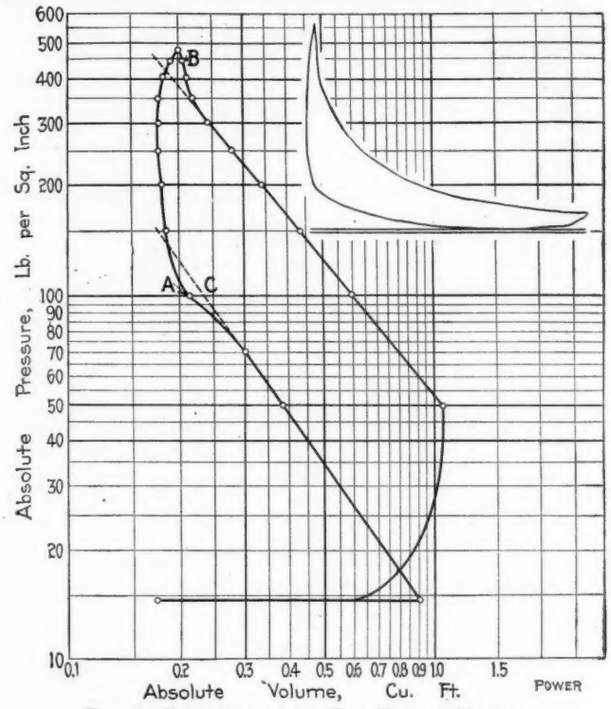


FIG. 5. DIAGRAMS FROM GAS ENGINE USING ILLUMINATING GAS

DETECTING LEAKAGE

It has been pointed out that the expansion and compression curves will become straight lines in the logarithmic diagram only when the weight of fluid acting remains constant. They will not be straight lines, therefore, when the quantity of fluid acting is being changed by leakage into or out of the cylinder.

Except in the highly improbable case, where the leakage into just replenishes the leakage out of the cylinder, the effect of leakage will be to distort the expansion and compression curves so that they do not become straight lines on the logarithmic diagram.

Fig. 5 is a diagram from a 10x10-in. gas engine intended for producer gas but using illuminating gas, which, with the high compression, produced a high initial pressure. The piston, a single-acting trunk type, allowed a large leak, evidenced by the noise of escaping gas at the commencement of the combustion stroke. Both the compression and the expansion curves show the effect of this leak very decidedly at *A* and *B* respectively.

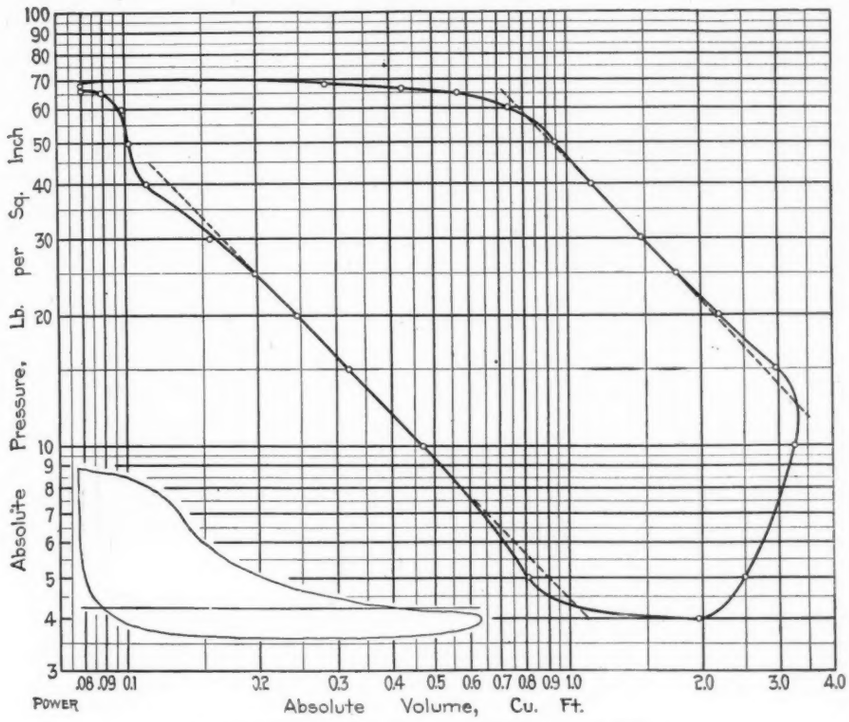


FIG. 6. DIAGRAM FROM LEAKY CORLISS ENGINE

Fig. 6 is from a 14x35-in. Corliss engine. The knowledge of the leaky condition of the piston and valves came from the engineer in charge. The expansion and compression lines indicate by their form at the upper ends a large leak from the cylinder, indicating a leaky piston or exhaust valve or both. The lines also show by the rising of the curves at the lower ends a considerable addition to the steam in the cylinder during expansion and compression. This steam could come only from a leak in the steam valve.

Fig. 7 is from an 11¼x22-in. double-acting ammonia compressor, the cylinder of which was known to be in very bad condition as regards wear and leakage of piston and valves. The reëxpansion curves, by the enormous amount of reëxpansion shown, indicate large leakage into the cylinder during this operation. The lower part of the compression curves, by rising, indicates leakage into the cylinder either past the piston or through the discharge valves. The upper part of these curves indicates leakage from the cylinder either past the piston or through the suction valves.

Very smooth curves may be obtained in the indicator diagram even if there is considerable leakage taking place. The expansion and compression curves of the *pv* diagram, Fig. 6, are fairly regular, but the logarithmic diagram shows plainly that large leakage of two kinds was taking place during expansion and compression. Leakage which takes place during admission or exhaust has no effect upon the lines of the diagram as the weight of the medium is continually changing.

In discussing leakage it must be kept in mind that difference in pressure between two regions is the cause of the phenomenon. In the steam engine there are three pressures which must be considered, that in the steam chest, in the cylinder and in the exhaust passage. Leakage, being due to difference in pressure, becomes material only when this difference becomes considerable. The leakage into or out from a steam cylinder has been found to occur in most cases only when the pressure difference is over about 20 lb.

In Fig. 6 the leakage into the cylinder, shown by the lower parts of the line, begins to occur at about 25 lb. absolute or 35 lb. lower than the pressure at admission. The leakage out from the cylinder, shown by the upper parts of the line, ceases to occur at a pressure of about 40 lb. absolute for the expansion curve and begins to occur at about 25 lb. absolute for the compression curve. The difference of pressure between the steam in the cylinder and that in the exhaust passage is about 35 lb. in the first case, and about 20 lb. in the second case.

This fact, founded upon many diagrams analyzed, permits the division of the expansion and compression lines roughly into three equal parts on the logarithmic diagram (when these lines extend from the initial pressure nearly to the back pressure): (a) the upper third, influenced by leaks *out from* the cylinder; (b) the middle third, practically *uninfluenced* by leakage; (c) the lower third, influenced by leakage *into* the cylinder. Thus fairly reliable values of *n* free from the effects of leakage may be obtained from the middle third of the lines. Ordinarily it is not possible to distinguish between two leaks occurring in the same third of the curves.

When only one kind of leakage exists it is possible to compute with fair accuracy the volume of leakage taking place during expansion or compression. In Fig. 5 the lines are extended (as shown dotted), giving the lines of constant weight of medium. If there had been no leak the volume at 100 lb. pressure would be that indicated by the intersec-

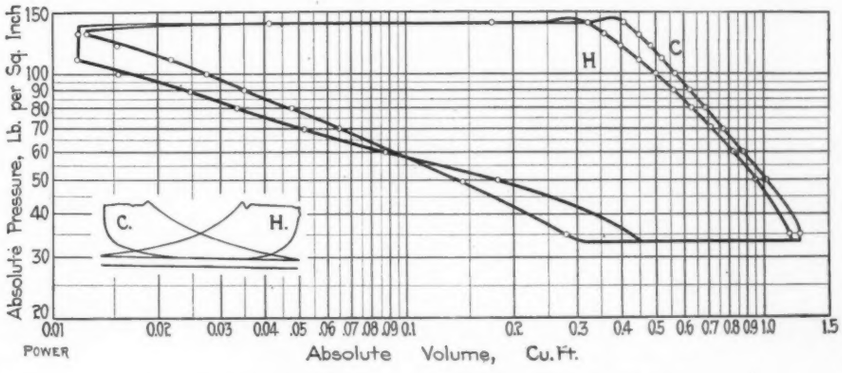


FIG. 7. DIAGRAMS FROM LEAKY AMMONIA COMPRESSOR

tion of the dotted extension of the compression line at *C*. The volume actually present is indicated by the location of the point *A*. The difference between the volume indicated by *A* and *C* is a measure of the leakage. The important thing, however, is the indication that leakage is taking place so that it may be stopped.

Determining the Clearance

The curves of the indicator diagram will become straight lines upon the logarithmic paper only when the pressures and volume are measured from absolute zero. If there is any mistake made in locating the line of zero pressure or the clearance line, the replotted expansion and compression lines will be curved. If the clearance is not known it may be determined by plotting the logarithmic diagram for a number of assumed clearances until the compression line becomes straight. This was done in Fig. 8, which is from a 42x60-in. gas engine using blast-furnace gas. Curves, both expansion and compression, were plotted for 14, 16, 18, 20 and 22 per cent. of clearance. With the true clearance of 18 per cent., the curves become straight lines. With values of the clearance less than 18, the curves become bent to the left; with the value above 18, to the right.

If the clearance is accurately known, the position of the line of absolute zeros of pressure may be located in the same way, thus determining the barometric pressure if the atmospheric pressure and the scale of the spring are given, or the scale of the spring if the atmospheric pressure and reading of the barometer are given. The compression line gives naturally the better indication, as shown by the wider spacing and more decided curvature of the compression curves produced with the erroneously assumed clearances in Fig. 8.

Steam Consumption from the Diagram

The indicator diagram shows the pressure of the steam in the cylinder at the point of cutoff. From the steam tables its weight per cubic foot at this pressure may be determined. Knowing the volume of the cylinder up to cutoff and the number of times it is filled per hour, it would seem that the weight of steam thus metered off could be computed; and it could if the contents of the cylinder at the instant of cutoff were all steam. As a matter of fact, the steam consumption computed from the diagram in this way will be from 15 to 50 per cent. too low because some of the entering steam has condensed upon the surfaces which have just been exposed to the cooler exhaust, and is present as water when cutoff takes place.

As the pressure is lowered by expansion below that corresponding to the temperature of this water, a portion of the steam is reëvaporated, changing the course of the expansion line, and the most significant point brought out by Mr. Clayton's paper is that the line remains a true exponential curve and that the value of *n* bears a definite relation in any given cylinder to the proportion of the total weight of steam mixture which was present as steam at cutoff.

Furthermore, the relation of *n* to this initial quality for the same class of cylinder as regards jacketing has been found to be practically independent of engine speed and of cylinder size. If one can determine then the exponent of the curve of a given diagram, and knows the quality of the mixture at cutoff corresponding to that exponent, he can compute from the diagram the amount of steam actually used by the engine with a degree of accuracy limited only by the accuracy with which these quantities are known.

The method of determining the value of the exponent from the slope of the expansion curve has already been explained.

In Fig. 9 is given a chart from which the quality at cutoff for any value of *n* between 0.85 and 1.25 and for any pressure at cutoff between 40 and 160 lb. absolute may be measured. For $n = 0.95$, for instance, the quality at cutoff is a little less than 0.51; at 60 lb. a little less than half way between the curved lines representing 0.56 and 0.58. At 100 lb. it is nearly 0.62, etc.

This chart is plotted from the results of tests upon a 12x24-in. Corliss engine exhausting into a condenser in order that the condensate might be weighed, but at about atmospheric pressure. The speed had a slight effect upon the quality at cutoff and the chart is plotted for 120 r.p.m.

The effect of a change of pressure on the relations of the quality at cutoff and *n* is not great between the limits of 75 to 150 lb. An approximate equation, correct for the conditions at 129 lb. absolute representing the average of the range mentioned, is

$$X_c = 1.245\, n - 0.576$$

where

X_c = Proportion by weight of the mixture present as steam at cutoff;

and

n = Exponent of v in the equation $pv^n = con.$

This quantity for the ordinary case will be less than unity, and dividing the weight per cubic foot of dry saturated steam at the cutoff pressure, as given by the steam table, by it will give the weight per cubic foot of the mixture. Multiplying the volume of the cylinder up

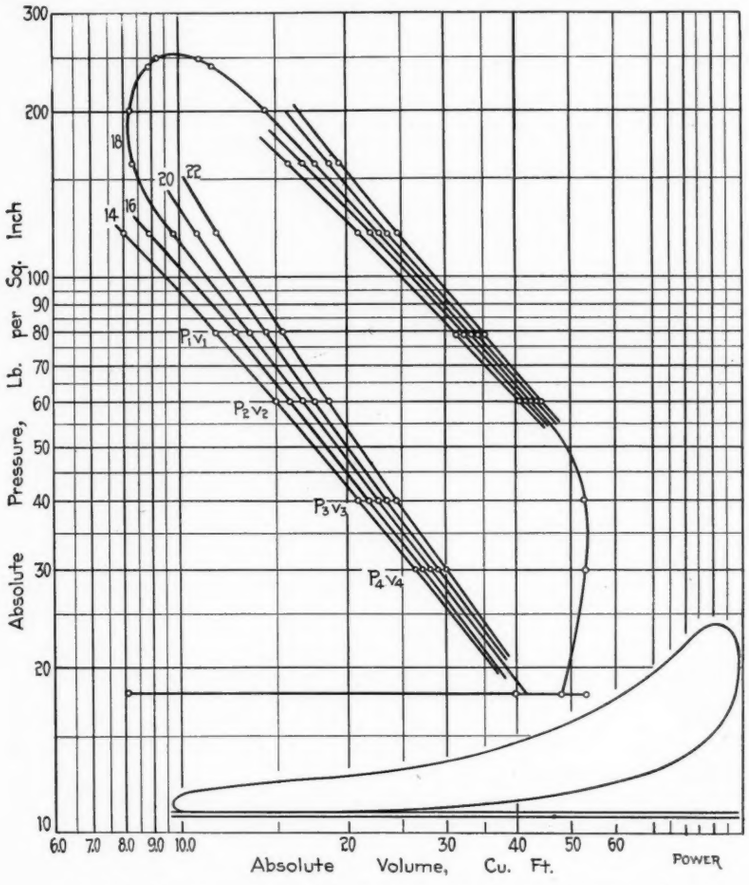


Fig. 8. Diagram from Gas Engine with Blast Furnace Gas

to the point of cutoff in cubic feet by the weight per cubic foot will give the weight of steam and water present in the cylinder at the point of cutoff.

But not all of this came in when the valve was opened for admission. There was some saved from the previous stroke by closing the exhaust valve before the stroke was finished. It has been demonstrated by George Duchesne* that this steam at the commencement of compression is dry saturated. After the exhaust valve has become fully seated and the weight of steam being compressed has become constant, the compression line will be straight upon the logarithmic diagram as between *A* and *B*, Fig. 3. If this line is projected downward as by the dotted line *BC*, the intersection with the back-pressure line of the diagram will indicate the volume of dry saturated steam of that pressure present. The weight of the volume at that pressure can then be taken from that present at cutoff and the difference will be the weight supplied per stroke, which multiplied by the number of strokes per hour will give the weight supplied from the boiler for that end of the cylinder.

The results of the applications made up to the present tend to show that the steam consumption of engines may be approximated from the indicator diagram to within an average difference of less than 4 per cent. from the test results. Individual examples, however, may show as much as 8 per cent. in rare cases. Further investigations of the relations of X_c and n with all types of engines running under all sorts of conditions may lead to the evolution of a set of tables or charts of these relations which can be used with confidence that they will give a sufficiently close approximation to the actual consumption of the engine to allow that consumption to be computed from the indicator diagram instead of laboriously being measured in an expensive test. An engine which would otherwise be tested perhaps once in its lifetime may have its water rate determined frequently with little more labor than is now spent upon the worthless uncorrected consumption from the diagram, and such easily made determinations may serve all the purpose of expensive tests except where large bonuses or forfeits are involved, and even in these cases would serve as a check upon the test figures.

The paper contains tables of results from tests of numerous engines, an explanation of the development of the chart shown in Fig. 6, diagrams from various engines, including the Diesel, the Stumpf unidirectional flow, combined diagrams from compound- and triple-expansion engines, and much material of value to the student of indicator diagrams.

*Power, Jan. 10, 1911, page 71.

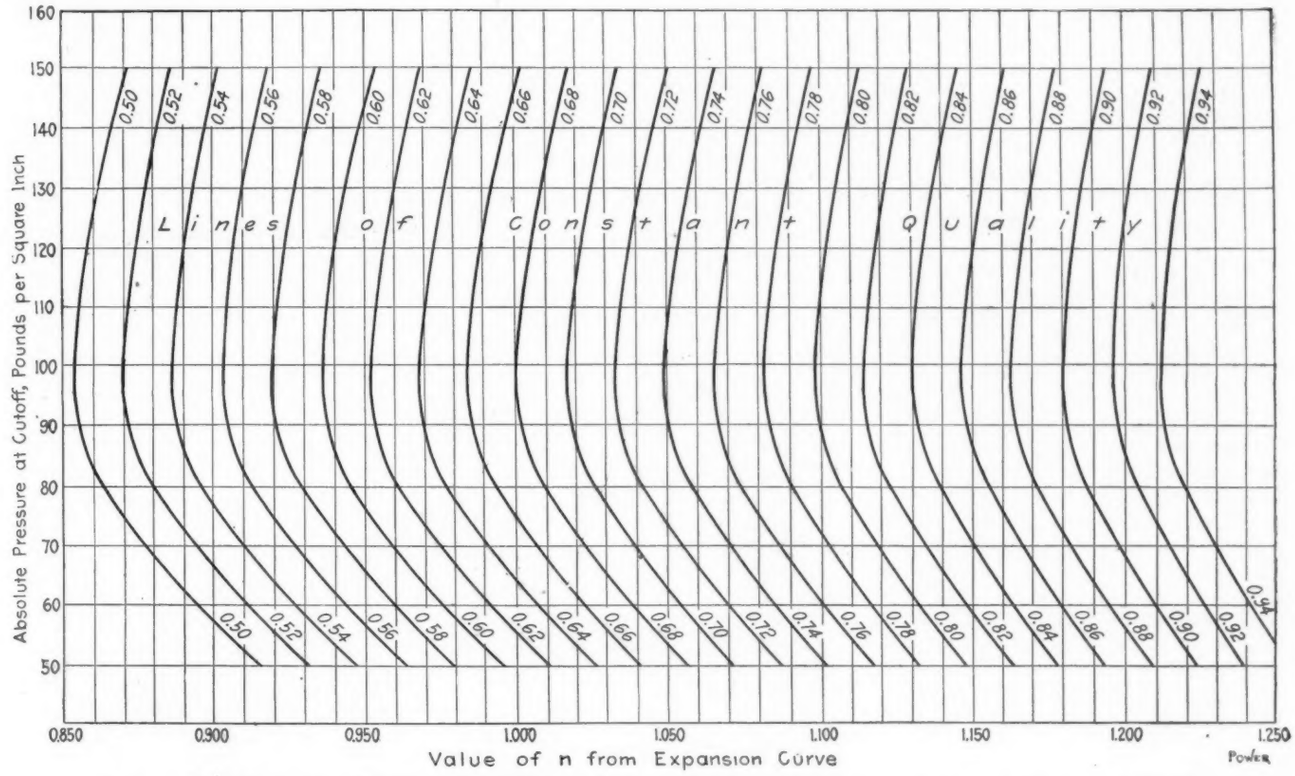


FIG. 9. THE RELATION BETWEEN PRESSURE AT CUTOFF AND VALUES *n* FOR CONSTANT QUALITY AT CUTOFF

For the year 1910, reports the Department of Mines of Western Australia, there were 58 gas engines in use in mines developing 607 hp., while 2933 hp. was developed by 420 oil engines.

Furnace Arches

BY W. H. BOOTH

Under the severe conditions to which brick furnace arches are subjected, it is a wonder that they last as long as they do. Many who have to deal with firebricks are content to purchase them from some convenient supply house and they may have been exposed to the weather and be saturated with moisture.

Damp bricks should never be put into a furnace arch, but should be stored in a place where they will be thoroughly dried out before using. If it is not possible to so store them, they should be kept as dry as conditions will permit and brought into a dry, warm place two or three weeks before being used. It is then possible to build an arch, using a little fireclay as a jointing material.

An arch should be given time to dry out slowly, first letting a gentle draft pass through the cold furnace and then maintaining a slow fire for several days.

Thin joints are essential to longevity, and this should rule out all bricks not properly tapered to fit the radius of the arch in order that the joints may be even throughout. The best fire arch bricks are those which taper lengthwise. Some are made with a horizontal projection on one side to fit as a key into an inverted hollow on the other side of the next brick. Any attempt to use rectangular bricks is fatal to rigidity as the bricks will ride together on the inner curve of the arch and will soon work loose and

collapse. If the jointing material is made into a grout into which the bricks are dipped, they may be rubbed together to exclude any surplus clay and a solid arch will result, if dried out slowly.

The side walls of a boiler setting must be capable of withstanding the lateral thrust of a flat arch. This stability can always be insured by stout supports of girder iron sunk below the ground and held together above the boiler by cross tie rods.

When carefully treated the furnace arch becomes cemented into a uniform mass by the fusion of the bricks, but this will occur only in a well built arch. When it does occur, it prolongs the life of the arch.

Safeguards for Power Plant Equipment

By Edward K. Hammond

A description of several devices for preventing accidents.

They are practical, and so simple that the ordinary engineer can make and install them at small expense.

Statisticians have estimated that, each year, from 30,000 to 35,000 wage earners in the United States lose their lives as the result of industrial accidents and that about 2,000,000 nonfatal accidents occur. Probably 60 per cent. of these accidents are either the result of the injured person's carelessness or are due to the absence of proper safeguards.

It is particularly true that the carelessness of any power-plant operator not only endangers his own safety but that of others; consequently new men should be instructed about the dangers incident to their work and the most rigid discipline maintained to enforce all precautionary measures. The importance of this careful attention can best be kept before the operator by hanging framed safety rules in conspicuous places in the plant.

Railed Walks

Where coal cars are switched to a trestle to deliver fuel to the bunkers, there are two possibilities for accidents; a man may be caught where there is no room for him to avoid the moving cars; or persons passing under the trestle may be injured by falling material. Fig. 1 illustrates a trestle where these dangers have been safeguarded. Railed walks have been provided along either side of the trestle with a platform between the tracks, the walks having base boards which prevent loose material from being kicked off the trestle, or a man slipping on the walk and falling under the hand rail. The standard calls for a walk 4 ft. 3 in. wide with a metal hand railing 3 ft. 6 in. above the walk and a toe board 6 in. high. If a driveway or walk passes under the trestle, the structure is completely planked over at this point.

Railed walks and permanent ladders leading to platforms which carry the operators within reach of all valves in the plant are good. Fig. 2 illustrates the interior of a plant so equipped. These walks not only save loss of time in shutting off the steam in case of an emergency, but also do away with the probability of serious falls. Railed walks are also used on each boiler in the plant and lead from boiler to boiler.

It is important to have two valves between the boiler and its header when two or more boilers are connected to it. A man cannot do good work in a boiler if he feels insecure, and no man should be exposed to danger for the sake of saving the extra expense of a second valve. A locking lever for preventing the accidental opening of valves on the boiler steam, feed and blowoff pipes while men are in the boilers making repairs or inspections is shown in Fig. 3.

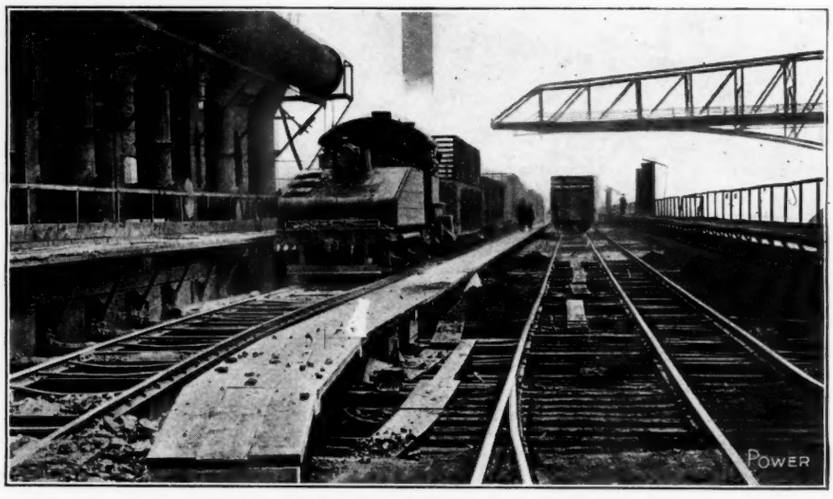


Fig. 1. Trestle with Railed Walks

To release this lever a man must use one hand to depress the spring and the other to throw over the catch *A;* this makes it impossible for a valve thus secured to be accidentally opened. A warning notice stating that the boiler is down is used in connection with this locking lever, the notice being hung on the closed valve. There is, therefore, no excuse for injury through the accidental opening of a valve. As a further precaution, however, it is advisable for a man about to enter a boiler to notify all of the workmen in that section of the plant.

Care of Boilers

After opening the manholes the damper should be opened to produce a current of air through the boiler and carry off any inflammable vapor. Accidents from explosions in boilers where kerosene has been used or where sewer gas may have entered will be avoided by observing this precaution.

Pipes discharging at points where passersby are likely to be scalded should discharge into exhaust pits and these pits should be covered with something suitable for the use over hot-water sewers.

It is of utmost importance that each boiler have a steam gage, so mounted as to make it possible for it to give accurate indications. In connecting a gage the piping should be as short as possible with nothing in the piping between the boiler and its gage except the gage-cock. In the piping should be a water-pocket that high-temperature steam may not come into direct contact with the bent gage tube and draw its temper, thus causing the gage to give incorrect readings. All of the gages in the plant should be calibrated at regular intervals to insure their accuracy.

Gage-glass Guard

Fig. 4 illustrates a guard to prevent injury to the man putting in a new gage-glass. This guard consists of a semi-cylindrical piece of sheet metal mounted on a pivot at either end so that it can swing around the glass. When a new glass is being warmed up, the guard is placed between it and the operator where it will protect him from flying pieces of glass and, to some extent, from the

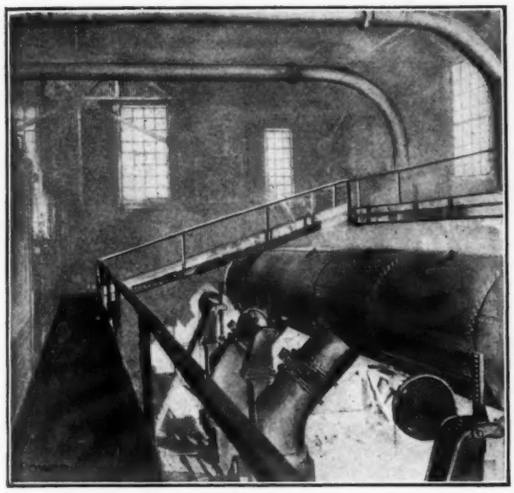


FIG. 2. RAILED WALK ABOVE BOILERS

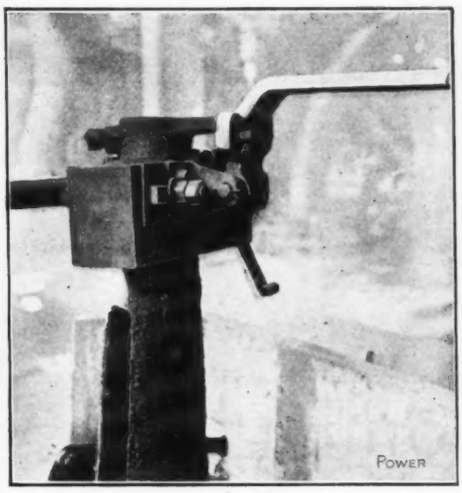


FIG. 3. LOCKING LEVER

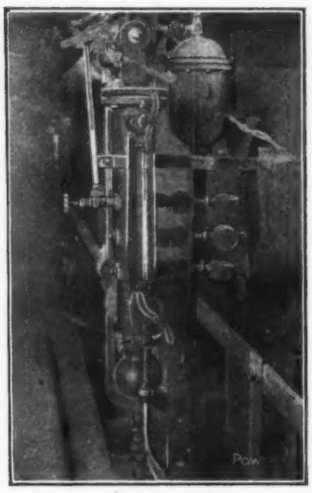


FIG. 4. GAGE-GLASS GUARD

steam and hot water if the tube bursts. After the new glass has been subjected to a fair test in this way, the guard is swung around to the back of the glass, where it does not obstruct the view. The guard is shown in this position. A lamp close to the gage illuminates it.

SCALE

Although scale frequently causes boiler accidents, some power-plant operators regard its formation as of little importance, but such an accumulation causes overheating of the plates, which reduces their strength. When heavy scale forms on the tubes and tube sheets the tube ends are burned and soon leak at their connection in the tube heads. Other dangers from scale in a boiler are incorrect water levels and pressure readings due to clogging of the pipes leading to the gages and of the feed pipes.

FLYWHEEL EXPLOSION

The most serious hazard connected with the operation of engines is that of the flywheel bursting, usually caused by centrifugal force. To minimize flywheel accidents correct design is the first essential, but even properly designed wheels may burst if run above their safe speed. Overloading causes a flywheel to fail because of the bending stresses in the spokes.

In addition to the danger from bursting, flywheels are a menace from the chance of accidental contact with them; therefore it is well to surround them with railings. Fig. 5 is a view in a power plant where the flywheel is thus railed off, a substantial metal guard being provided at the base to prevent a man slipping under the rail and into the flywheel pit. Railed stairs and walks are provided wherever it is necessary for an oiler to go on the engine.

Fig. 6 shows a turbine-generating set in which the flexible shaft coupling is completely inclosed; this keeps dirt away from the bearings and eliminates danger of a man being caught by the coupling.

ELECTRICAL SAFEGUARDS

While the precautions to be observed in the design and operation of electrical switchboards and equipment are too numerous to receive detailed treatment, certain rules are fundamental. All switchboards, dynamos and motors of over 250 volts should be thoroughly grounded, and surrounded by railings of a nonconducting material. The terminals and other parts of high-voltage dynamos and motors should be inclosed, or so arranged as to preclude possibility of an operator touching them directly or with a conducting tool.

Several good features may be seen on the electrical equipment in Fig. 7. The switchboard operator stands on a rubber mat placed on a wooden platform. Use of rubber mats around all machines is strongly advised, thus reducing the

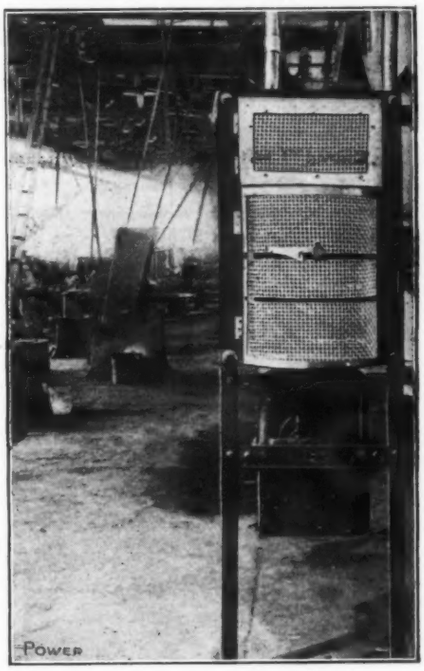


FIG. 8. SWITCH GUARD

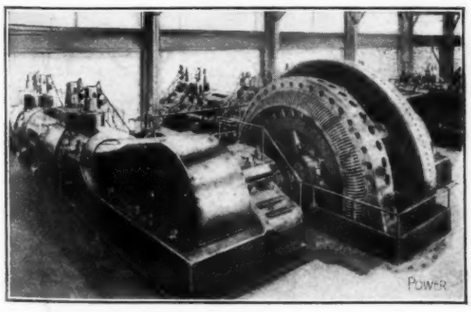


FIG. 5. GUARDED GENERATOR SET

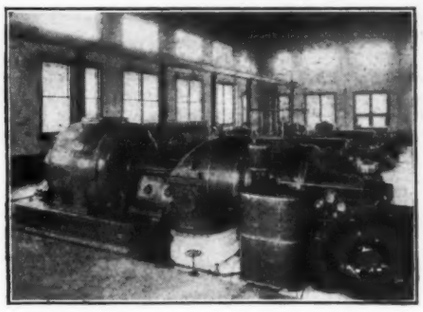


FIG. 6. HOUSED TURBINE COUPLING

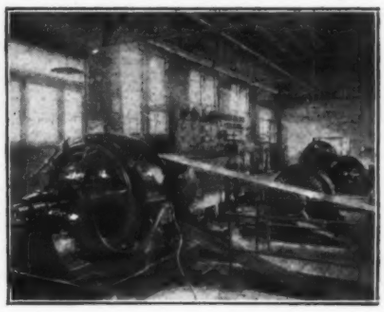


FIG. 7. BELT GUARD

chance of an operator slipping and being injured by moving parts. At the back of the switchboard ample working space has been left, and this is always kept unobstructed. When working on the board the operator should use rubber gloves, and switches should be provided to make the board "dead" when such work has to be done. Many plants provide for shutting off the space at the back of the switchboards whenever men are not engaged in making repairs and adjustments. Guard rails are shown at each belt driving the generators.

Fig. 8 illustrates another safety device which incloses the electrical switches in the factory so that men ignorant of their danger cannot be injured.

Inspection

All of the equipment in the power plant should be inspected at regular intervals. Whenever a boiler is put out of commission, a complete inspection should be made, the plates examined for cracks, the stays tested for tightness and the drum connections examined for pitting. Flywheels should also be carefully examined for cracks which usually develop in the under side of the rim near the spokes and if not detected will gradually increase in size and cause the wheel to fail.

Signed inspectors' forms on which is reported the result of all inspections are valuable as they can be filed for reference and in case of accident, make possible placing responsibility for any negligence where it belongs. The normal influence of such a system tends to keep the inspecting from being slighted.

The Bloomington Boiler Explosion

A press report of this locomotive-boiler explosion was published in the May 7 issue, but the following details were then unavailable:

At about noon of Sunday, Apr. 21, engine No. 127 was drilling in the Monon yards at Bloomington, Ind., when the boiler exploded, hurling the engineer through the box car, shown in Fig. 1, and killing him instantly. The fireman was standing on the tender at the time and was thrown over a caboose, landing about 75 ft. away; though seriously injured, he is said to be recovering. It was a Baldwin locomotive, dated April, 1892, and numbered 12,617, and was rebuilt and used for drilling purposes only up to the time it exploded. It is said that the engine was condemned a short time prior to the explosion.

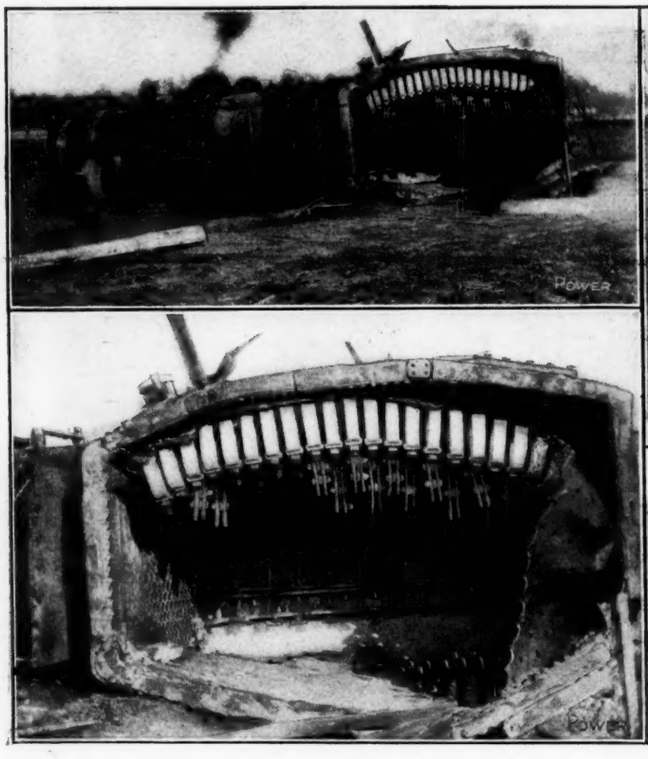
A locomotive boiler explodes in Bloomington, Ind., killing the engineer and seriously injuring the fireman.

The shell is stripped of all piping and attachments, the crown sheet torn away and the shell hurled 240 ft. The tubes were but slightly distorted.

The cause of the explosion is as yet unknown, but much lime deposit in the form of scale was found about the boiler near the spot at which the explosion occurred, showing that it was heavily scaled.

All the piping and attachments (Figs. 1 and 6) were stripped from the boiler, leaving only the shell and firebox intact. The air pump, however, was carried with the boiler for a considerable distance before it was torn from the shell and imbedded itself in the earth 350 ft. away. It appears that the pump was partially torn from the boiler at the moment of the explosion and when the latter turned over in the air the pump was then severed.

As the explosion was downward through the firebox, the trucks, engine cylinders, etc., remained on the track and were but slightly damaged. It is peculiar that the tubes were so slightly distorted (see Figs. 3 and 6). Despite the fact that the piping and attachments were cleanly cut from the shell, its only appreciable damage was to the crown-sheet, which was torn away and lodged in front of the firebox (Fig. 2).



Figs. 1 and 2. Showing Firebox

Figs. 3 and 4. Interior of Firebox and Location of Parts After Explosion

FIG. 5. WRECKED FREIGHT CAR

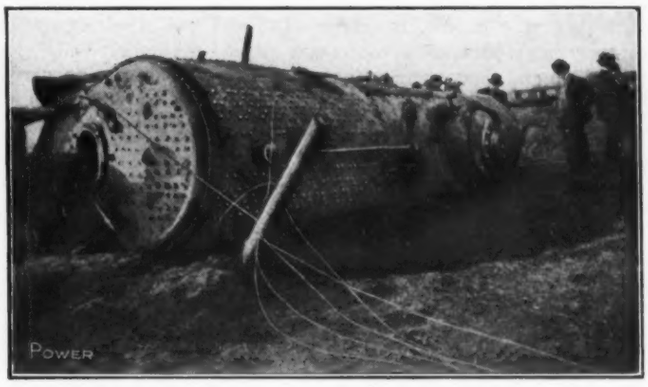


FIG. 6. SHOWING SHELL INTACT

Fig. 4 shows a general view of the yards. The arrow *A* indicates the location of the locomotive at the time of the explosion; the locomotive shown at this point is of the same type as the one wrecked. Arrow *B* shows the boiler resting against a fence about 240 ft. distant, and arrow *C* gives the position of the air pump which is so deeply imbedded in the earth as to be almost indistinguishable in the photograph.

The Solignac-Grille Boiler

A water-tube boiler in which the steam in formation does not pass through the water.

The entire boiler may be turned on a pivot out of the setting.

Among boilers employing small-diameter water tubes for rapid steaming, the new Solignac-Grille boiler, made by Grille & Co., Paris, France, presents some original features in its circulating and superheating systems, and the means employed for cleaning the tubes. The manner of circulating the water and passing the steam through the tubes is quite different from that employed by other boilers. One novelty is the introduction at the feed-water end of the tube of a supplementary resistance, preventing escape of steam in a direction to interrupt the inflow of water and admitting water only as fast as it can be vaporized in the tube.

Before describing the boiler, it might be well to briefly outline the experimental demonstration of the reasons for adopting a device to insure regular circulation, which were given at some length by *Engineering* in an abstract of a paper read by G. Hart before the Institution of Naval Architects.

Investigations on water circulation in boilers by Mr. Bellens have shown that the evolution of steam is not continuous, but intermittent and in the form of very large steam bubbles. By means of a sighting hole fitted with a glass cover it was also shown that the water descends between two escapes of steam by the path of this escape. It was to do away with such spasmodic emissions of steam and reverses of direction that Mr. Solignac conceived the idea of fitting at the lower end of the tube a diaphragm creating a supplementary resistance which should prevent any escape of steam at the lower end.

As a basis for this design he took the result of the following experiments: Two similar vessels, such as are shown in Fig. 1, were placed in the same horizontal plane and connected by a horizontal metallic tube. The tube was heated and the steam escaped intermittently from the two ends. The heated portion became red hot and the water which the tube contained was converted into steam. This steam escaped as often as its pressure exceeded the resistance caused by the head of water above the tube; then it escaped with a sudden rush and each time water again filled the entire tube. When the water rushed into the tube, a rapid hammering could be heard, which decreased as the temperature of the feed water rose.

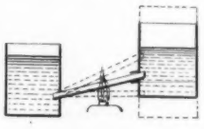


FIG. 1

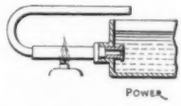


FIG. 2

By carefully raising one of the vessels so as to give more inclination to the tube, the phenomena were modified according to the inclination. As long as it was slight and did not exceed the diameter of the tube the effects observed were nearly the same as when the tube was horizontal, but as the inclination of the tube increased a larger quantity of steam escaped at the side next to the upper end, while the water in the vessel on this side was also heated to a higher temperature.

That the escape of steam was never regular, and had periods of variable intensity, was shown by hanging on the upper end of the tube a small thin shutter, which lifted with each discharge of steam. While there was only an occasional escape of steam from the lower end of the tube, a liquid film of viscous appearance could be seen descending in it just prior to each discharge of steam at the upper end. With the same apparatus a reducing diaphragm was fitted at the lower end of the tube and the phenomena of circulation became quite different. Steam then escaped continuously from the free end. The tube no longer became red hot, the water in the vessel on the diaphragm side remained cold and the water in the other vessel was heated rapidly. Finally, the level of the water became lower in the vessel on the diaphragm side and rose in the other an amount varying with the inclination of the tube. This experiment was supplemented by another with the bent tube shown in Fig. 2. The same phenomena were observed and the same results obtained, indicating that the diaphragm is the proper regulating device to afford a continuous flow of steam.

The sectional view, Fig. 3, reveals the general design and arrangement of the boiler, consisting of a horizontal drum with two attached compartments into which the tubes are expanded. Water is admitted into the lower compartment *A* through a valve *B* and its flow into the tubes is restricted by the diaphragm previously mentioned. Steam escapes from the tubes into the upper compartment or steam chest *C* and passes into the main drum from which the supply of water is drawn. The steam, not being compelled to cross the water surface but escaping above it, is much drier than in boilers where it has to pass through the water. The proportion of moisture is very small,

not exceeding a few thousandths. The arrangement does away with tumultuous ebullition and consequent rushes of water, particularly as the main drum and steam chest are not exposed to intense heat, and repairing the brickwork surrounding the boiler.

For marine service preheating of the air supply is possible by using double walls. The external facing plates of the boiler opposite to the furnace are composed of riveted sectional cells inside of which refractory brickwork is built up. Through these sections air is passed before entering under the grate so that the ashpit doors, having but little air to supply, are very seldom used in ordinary service. This arrangement has the advantage of cooling the external facing plates while preheating the air, and this constitutes a means of recovering part of the heat wasted by radiation. The air entering the cells can be controlled by movable shutters according to the intended rate of combustion.

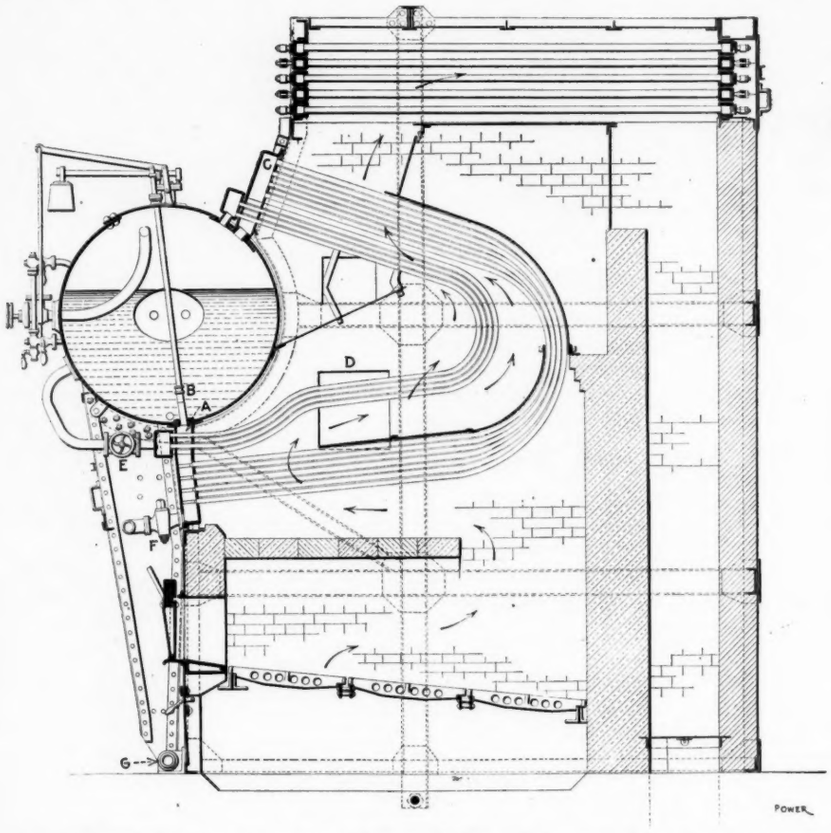


FIG. 3. SECTIONAL VIEW THROUGH GRILLE BOILER, EQUIPPED WITH SUPERHEATER AND ECONOMIZER

as may be seen from the path of the gases of combustion, indicated by the arrows in the illustration. The superheating tubes are shown at *D* and may be made auxiliary to the regular heating surface by flooding them through the valve *E*.

Next to the diaphragms the manner of cleaning is most interesting. The valve *B* is closed, shutting off the main drum from the lower compartment. Then by opening valve *F* steam under boiler pressure from the upper compartment flows in a reverse direction through the tubes and blows out the scale. The tubes, now containing no water, become hotter than normally and expanding loosen the scale which is readily carried away through the blowoff valve. The tubes are only left 30 sec. without water, which is long enough to detach the scale without injuring the tubes. The cleaning is made still easier by the division of the tubes into several groups, each corresponding to an element of the boiler shell, the various elements having nothing in common but the steam and water chests.

A third feature, which is altogether unusual, is a device which allows the whole boiler and the group of tubes to be swung around a pivot *G* for inspecting

Numerous tests on this boiler have shown the rate of combustion with a maximum output to average about 30 lb. of coal per square foot of grate, which would give an evaporation from feed water at 55 deg. of approximately 9 lb. of water. With a very slight reduction of efficiency, the rate of combustion may be increased to 40 lb. per square foot of grate. The boiler is a quick steamer, occupies comparatively small floor space, has the advantage of easy internal cleaning and, above all, produces dry steam, which becomes especially valuable where steam turbines are used aboardship.

Improved Pratt Trap

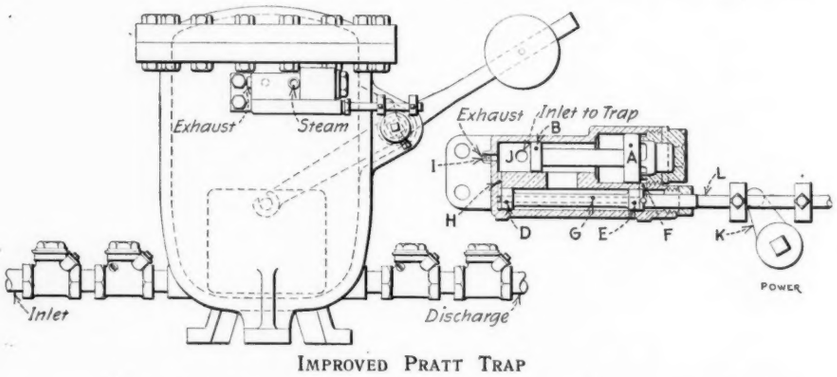
This trap consists of a cast-iron body containing a cast-iron float which works on a trunnion arm. The float is balanced on the outside by a weight and lever, the lever operating the valve mechanism, which is bolted to the side of the trap; its function is to alternately admit steam to the trap or exhaust it to the atmosphere.

Steam enters the side of the valve casting between the pistons *A*, *B*, *D* and *E*, and the piston *A*, being of larger area than the piston *B*, is forced to the right. The right side of the piston *A* is connected to the exhaust through the ports *F*, *G*, *H* and *I*. The small piston *B* is exposed to the exhaust on the left side. In this position the interior of the trap is connected to the atmosphere through the ports *J* and *I*.

Condensation enters the trap through the left check valves and in filling it the float gradually rises and the lever *K* moves the valve rod *L* toward the right until the position of the valve is such that the steam will enter the port *F* to the right side of the piston *A* and force it to the left, thus connecting the port *J* with the steam chamber.

Steam then enters the trap above the water and balances the boiler pressure on the discharge side, with the pressure in the trap, which then discharges to the boiler by gravity.

This trap is manufactured by the Pratt & Cady Co., Hartford, Conn.



IMPROVED PRATT TRAP

Electrical Department

Conducted to be of service to the men in charge of electrical equipment in the power house

Transformer Connections

By Cecil P. Poole

Testing for Three-phase Connections

In connecting transformers either delta- or star-fashion, care must be taken to make the secondary connections correspond exactly with the primary connections as regards relative polarities and phase "rotation." If this is not done, a short-circuit may be caused with delta-connected secondary windings and incorrect voltages will be obtained with star-connected secondary windings.

When the primary and secondary leads are both connected in delta or both star-connected, it is an easy matter to get the connections right. It is only necessary to get the primary terminals connected up properly, as described in the

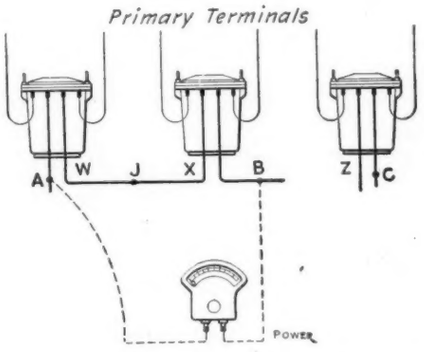


Fig. Testing First Transformer for Three-phase Connection

preceding article (May 14 issue), test the secondary winding of each transformer to ascertain the instantaneous polarity with respect to its primary terminals, as described in the first article, on single-phase connections (May 7 issue), and then connect the secondary leads from the three transformers exactly as the primary leads have been connected.

If the primary terminals of the transformers are delta-connected and it is desired to connect the secondary terminals star-fashion, or when the primaries are star-connected and it is desired to connect the secondary windings in delta, the method just outlined cannot be applied, because of the difference between star and delta connections. In such cases, the primary windings should be connected up permanently, just as they are expected to be operated, and the secondary connections tested out as follows:

For delta-connected secondary windings, twist one secondary lead from one transformer to one of the leads from the next transformer, temporarily, as indicated in Fig. 1, and measure the voltage between the two free secondary leads, *A* and *B*. If it is the same as the voltage between the twisted joint *J* and either of the terminals *A* or *B*, of the transformers temporarily connected, this connection is correct and the joint *J* should be made permanent. If, however, the voltage between the two free terminals *A* and *B* is about 1¾ times the voltage between the joint *J* and either one of the terminals, then the connection is wrong and the free terminal *B* of the second transformer should be connected to the joint lead *W* of the first one instead of the lead *X*.

Having connected the first two transformers properly, attach one of the leads of the third transformer to the free terminal of the second one and measure the voltage between the free leads of the first and third transformers, as represented in Fig. 2, where these free leads are marked *A* and *C*. If the connection between the second and third transformers is right, the voltage between the free leads *A* and *C* will be the same as the voltage between the two leads of any one transformer, as *A* and *W*, or *B* and *X*, or *C* and *Z*. If it is wrong, the voltage between *A* and *C* will be about twice as great as the voltage between the two

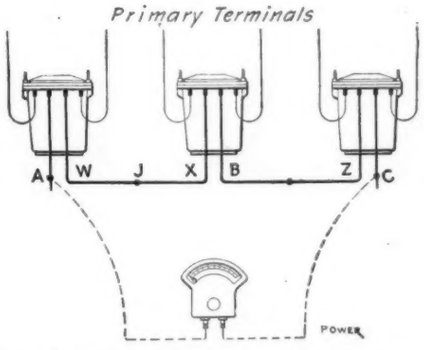


Fig. 2. Testing Third Transformer for Delta Connection

leads of any one transformer; in that case, the leads from the third transformer must be reversed, the lead *C* being connected to the lead *B* and the lead *Z* to the lead *A*.

For star-connected secondary windings, twist one lead of the first transformer to one lead of the second transformer as before and measure the voltage between the two free leads of those two transformers. In this case, that voltage should be about 1¾ times the voltage of any one transformer (theoretically, 1.732 times the transformer voltage). If it measures the same as the voltage of one transformer, the connection is wrong and the leads from the second transformer must be reversed, connecting the lead *B* to the lead *W* and leaving the lead *X* to be connected to the third transformer.

The next step is different from that of the test for delta connections. After the

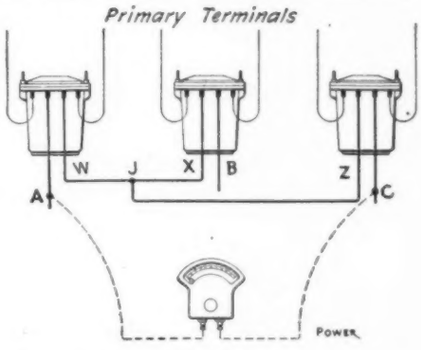


Fig. 3. Testing Third Transformer for Star Connection

first two transformers have been connected properly, one lead of the third transformer must be connected to the joint *J*, as shown in Fig. 3, and the voltage measured between the free leads *B* and *C*, or between the leads *A* and *C*, it matters not which. If this voltage is about 1.7 times the voltage between the joint *J* and any one of the free leads, then the connection is right and should be made permanent. If the voltage between two of the free leads is equal to that between the joint and one of the free leads, the connection is wrong and the leads from the third transformer must be reversed, the lead *C* being connected to the joint *J* and the lead *Z* left free.

Changing the Number of Phases

It is sometimes desirable to change three-phase currents to two-phase currents, or *vice versa,* and this is usually done by the use of the system of connections shown in Fig. 4, which is commonly known as the "Scott connection" because it was originated by Charles F. Scott, at that time chief electrical engineer of the Westinghouse Co. Two transformers are used and they are interconnected as indicated in the diagram, one primary terminal of one being connected to a tap leading out from the middle

of the primary winding of the other, and about 13 per cent. of the primary winding of the first one being omitted from the primary circuit. As this diagram is drawn, the transformers receive their primary currents from a three-phase circuit and deliver two-phase secondary currents. The arrangement works just as well in the reverse direction, however; if two-phase currents are delivered to the two-phase terminals of the transformers, three-phase currents will be delivered from the three-phase terminals. Moreover, the transformers can be so connected as to receive high-tension two-phase currents and deliver low-tension three-phase currents. For this purpose, the primary leads are connected up exactly as the secondary leads are shown in Fig. 4 and the secondary leads and windings are connected up in the way which this diagram shows for the primary windings and leads.

There are other methods of changing three phases to two, or *vice versa,* but none of them is as simple or as advantageous as the Scott method, and they are seldom used.

Six-phase Connections

For supplying current to rotary converters, transformers taking current from

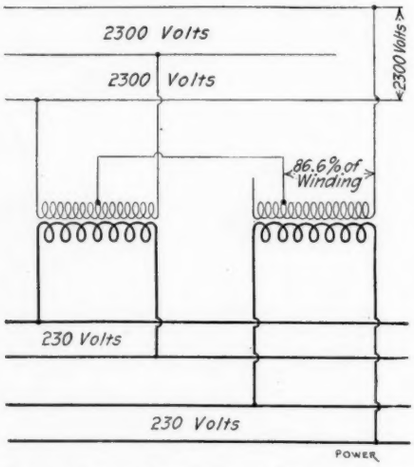


Fig. 4. Scott Connection for Changing Three-phase to Two-phase, or the Reverse

three-phase primary circuits are sometimes connected so as to deliver six-phase currents to the converter. Two methods of doing this are in general use. The simplest method is to carry the six secondary leads from the transformers to the converter without interconnecting them at all, as represented in Fig. 5. Tracing the connections will show that each pair of secondary leads is connected to points in the armature winding of the converter which are at opposite ends of a line drawn straight across from side to side of the armature, through its center; the secondary leads from the *A* transformer, for example, are connected (through brushes and slip rings) to the points *a* and *a'* of the armature winding, and these are at opposite ends of an imaginary horizontal line from one side through the center to the other side of the armature, at the instant represented by the diagram.

The armature shown is that of a bipolar machine, for simplicity. In a multipolar machine there would be three times as many armature taps as there were field magnet poles, but as these do not go beyond the slip rings they do not affect the transformer connections, and it is these with which this article has to do. There are only six slip rings and brush leads on a six-phase converter, no matter how many field magnet poles it may have.

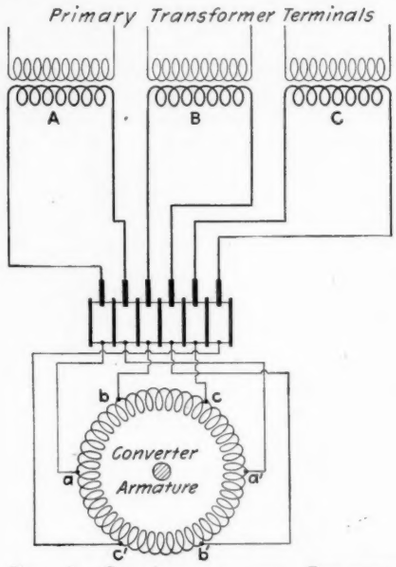


Fig. 5. Connections for Delivering Currents with Standard Transformers

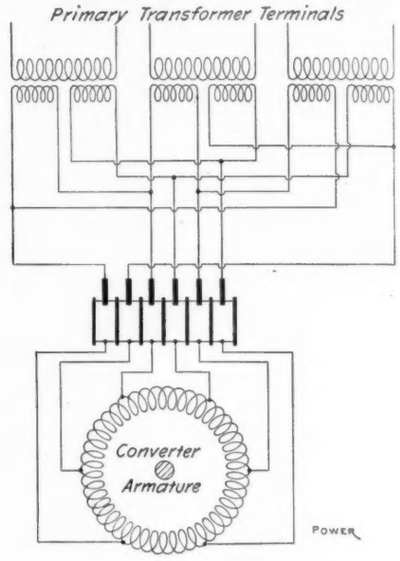


Fig. 6. Six-phase Connections for Double Transformer Secondaries

Fig. 6 shows the other method of connecting three transformers for delivering six-phase currents to a rotary converter, which is commonly used. It requires two secondary windings on each transformer and is more complicated so far as making the connections is concerned. Each set of secondary transformer windings is delta-connected and the three leads from each set are connected to three points in the armature which are at equal distances from each other; the three leads from one set of secondary windings alternate with those from the other set.

The two sets of transformer secondary windings are connected oppositely with respect to each other. This is necessary on account of the interspacing of the two sets of leads at the armature winding of the converter. The same result could be obtained by changing the order in which the second set of secondaries is connected and not reversing the terminals of each half secondary, but that would be more complicated than the connections shown in Fig. 6.

The connections in Fig. 5 are nothing more or less than three single-phase connections displaced 120 electrical degrees from each other. There are not six phases until the armature winding is reached, where the intermingling of the three currents produces six phases within the winding.

The connections shown in Fig. 6, however, produce six phases right at the transformer terminals, each displaced 60 electrical degrees from the nearest other one. Testing out the connections from transformer to transformer with this arrangement is rather tedious, but not as difficult as the complicated appearance of the diagram would cause one to expect. One set of secondaries is tested out and connected up exactly as explained for the simple three-phase delta connection; then the other set is connected up in exactly the same order but with each pair of secondary leads "crossed" or transposed. This is illustrated by Fig. 7.

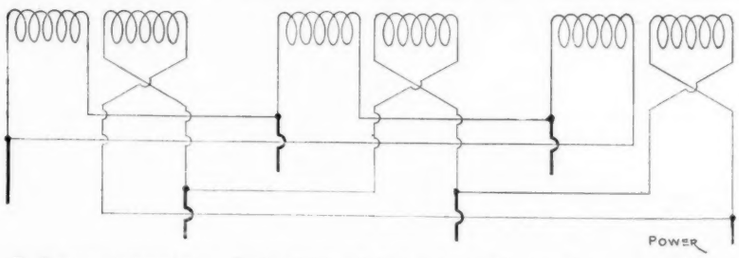
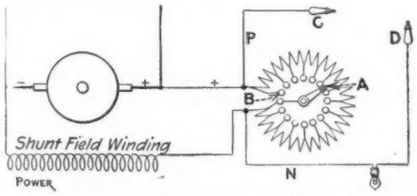


Fig. 7. Illustrating the Principle of Six-phase Connections of Double Secondaries

LETTERS

A Convenient Source of Test Voltage

In making repairs to armatures, commutators, etc., it is very convenient to have a source of low-voltage current for testing purposes. The accompanying diagram indicates a method of obtaining a suitable voltage in plants not having batteries or generators especially designed for this purpose. The method consists simply in connecting the test leads, which include an incandescent lamp, in parallel with the generator field rheostat, as shown. The test voltage is determined, of course, by the drop across the resistance of the field rheostat and this can be varied slightly, if necessary, while the test is being made.



CONNECTIONS FOR TEST VOLTAGE

If it should happen that the normal voltage drop across the rheostat terminals is so much too high that a suitable voltage cannot be obtained by adjusting the rheostat arm slightly, it can be got by shifting one of the test leads from the terminal post to one of the contact buttons between the arm and the last "live" contact button. For example, the lead *P* could be attached to one of the buttons between the arm *A* and the end button *B*. The voltage should be high enough to light the test lamp when the testing points *C* and *D* are touched together, and not high enough to strain or break the filament. By using this method no other resistance than the lamp is required, and the leads can be quickly connected.

P. L. WERNER.

McKeesport, Penn.

Commutator Lubrication

Mr. Barrick's letter has us all guessing. I think there is a great difference in dynamos in this respect, and one will work under certain conditions where perhaps another of the same make will fail. I have a compound-wound exciter with which I have to use brushes having a large percentage of graphite in order to make it run at all. On the other hand, in another plant a dynamo working under the same conditions gives no trouble with carbon brushes and a few drops of cylinder oil once a week is all that is required.

One good way to make a carbon brush run smoothly that has been run for some time and hardened is to wash it in gasoline, then soak it in olive oil for 24 hours, after which hang it in a warm place until dry. To clean a commutator that is not scored, moisten a cloth with a little kerosene and wipe lightly when running.

V. C. WOOD.

Copenhagen, N. Y.

In answer to Mr. Barrick's letter in the Apr. 30 issue, I have found that vaseline applied to the commutator with a nonlinting cloth is very satisfactory. There is also a good compound on the market which, as far as I know, is composed of graphite and paraffine. It is in stick form and is applied after the commutator has been wiped clean with a dry rag. After applying it the commutator should be wiped clean again after a short interval.

EUGENE M. HILBERT.

East Rutherford, N. J.

Careless Switchboard Connections

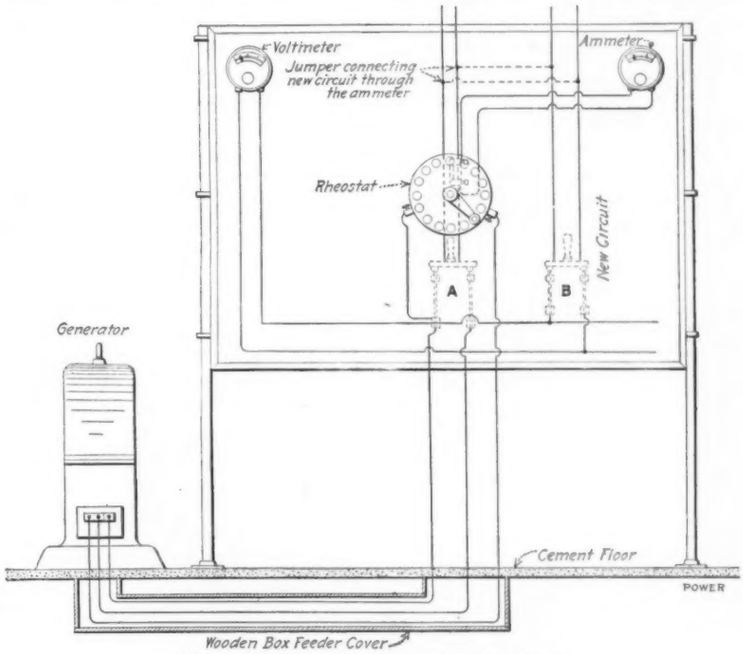
Some time ago I visited a small plant just in time to get a little experience that does not happen every day. This plant contained a 20-kw. direct-current generator used for lighting only and such appliances as are necessary for a machine of this size. Suddenly the lights began to get dim, the engine began to show distress, with plenty of steam registering on the gage, and the engineer tried in every way he knew to raise the voltage, but without success.

I suggested that a cross or short-circuit had occurred somewhere, but at that instant the proprietor came rushing in and he assured us that it could not be a line trouble because he had done all the wiring himself.

I looked around behind the switchboard and the accompanying drawing shows what I found. A new circuit had been put in the day before, but had not been used during the previous night. This circuit was connected to the terminal screws holding the leads coming from the generator to the switchboard so that only a part of the real load was showing on the ammeter. Temporary connections were made by the engineer, as shown by the dotted line, and the switch *B* was opened; 45 amperes more were indicated by the ammeter than had been shown before.

HUGH L. RUSSELL.

Keams Cañon, Ariz.



WIRING CONNECTIONS ON SWITCHBOARD

Motors Will Not Carry the Load

I have a 7½ two-phase induction motor operating an elevator. The bearing next to the pulley became so worn that the rotor came in contact with the stator, causing the insulation to break down. The bars of the rotor are fastened to the short-circuiting rings by screws. After removing each bar and insulating thoroughly I replaced them and put the motor in operation. The motor runs all right until there is a load applied and then it drops much below normal speed and will hardly pull the load. I have failed to find any loose connections and the motor does not heat when in operation.

I had another motor of the same type except that the bars were held in brass disks at each end and were soldered. This motor persistently threw its solder on one end and caused a bad connection between the bars and the disks. The other end runs without heating. This motor also refuses to pull a full load.

Will some reader enlighten me regarding the trouble?

Hopkinsville, Ky. J. L. SHRODE.

Gas Power Department

Worth-while gas-engine and producer information treated in a way that can be of practical use

Properties of Natural Gas

Thomas R. Weymouth, in a paper read at the recent meeting of the American Society of Mechanical Engineers in Cleveland discussed to some length the properties of natural gas and submitted a table showing the analyses of gases from the principal gas fields of the United States.

A striking feature of the table was the apparent lack of uniformity in the composition of the gases from different fields, and the great preponderance of hydrocarbons, especially of the methane or paraffin group. This has the general chemical formula C_nH_{2n+2}, its chief member being methane or marsh gas (CH_4). The percentage of methane was shown to vary from 14 to 97, although the lower figures applied to only a few special cases. It possesses a high heat value, but has practically no illuminating properties.

Without attempting to print the table in full and excluding those samples that came from shallow wells and were otherwise abnormal, the following is an average of the samples tabulated:

TABLE 1. COMPOSITION OF AVERAGE NATURAL GAS

Methane (CH_4)	87 per cent.
Ethane (C_2H_6)	6.5 per cent.
Ethylene (C_2H_4)	0.2 per cent.
Carbon monoxide (CO)	0.2 per cent.
Hydrogen (H_2)	trace
Nitrogen (N_2)	5.5 per cent.
Carbon dioxide (CO_2)	0.5 per cent.
Helium (He)	0.1 per cent.
Oxygen (O_2)	trace

B.t.u. per cublic foot, at a pressure corresponding to 29.82 in. of mercury and at 60 deg. F. = 887.3; specific gravity = 0.6135.

Heat Value

It was pointed out that the heat value of natural gas depends principally upon the relative proportions of methane, ethane, and the inert gases such as nitrogen and carbon dioxide. The only satisfactory method of ascertaining the heat value is by calorimetric determinations, but as this is not always convenient, the next best procedure is to compute it from the chemical analysis of the gas, using the value shown in Table 2 for the heat values of the constituent gases. This is done by multiplying the percentage of each gas by its corresponding heat value per cubic foot and adding the products. The specific gravity may be obtained in a similar manner.

It is sometimes desirable to obtain an approximate knowledge of the heating value of the gas when neither a calorimetric determination nor a chemical analysis is available. In such cases a close approximation may be made from the specific gravity of the gas, provided it is known to be a normally dry* gas without freakish tendencies.

The specific gravity may be determined readily by the "effusion" method, in which the time required to pass a given quantity of the gas through a pin-hole orifice in a thin plate, under a given pressure, is divided by the time required to pass the same quantity of air through the same orifice under the same pressure; the square of the quotient is the specific gravity of the gas referred to air. For most reliable results the gas and the air should be at the same temperature.

Mr. Weymouth gave an approximate formula for determining the heat value from the specific gravity of the gas. From the average analysis given in Table 1, it will be seen that of the combustible gases, methane and ethane, comprise 93.5 per cent. of the whole and ethylene and carbon monoxide comprise 0.2 per cent. each. No great error is made, therefore, if the two latter gases are considered as being part of the paraffin group, especially since ethylene and ethane do not differ greatly in either heat value or specific gravity. The inert gases may likewise be combined in one group, the resulting specific gravity of which may be considered equal to 1. Consequently, for approximate results the natural gas may be regarded as made up of three distinct gases, namely: methane, ethane and "inert" gases. Their respective heat values and specific gravities are as follows:

TABLE 2

	B.t.u. per Cu.Ft.	Sp.Gr.
Methane	897	0.5529
Ethane	1594	1.0368
Inert gases	....	1.0000

Representing the relative volumetric proportions of these gases, expressed decimally, as m, e and i respectively, the following relation will obtain:

$$m + e + i = 1.0 \quad (1)$$

$$H = 897\,m + 1594\,e \quad (2)$$

$$G = 0.5529\,m + 1.0368\,e + 1.0\,i \quad (3)$$

where

H = Lower heat value in B.t.u. per cubic foot of natural gas at 29.2 in. of mercury;

G = Specific gravity.

Combining equations 1, 2 and 3, the heat value may be found in terms of i and G as in equation (4).

$$H = 1440\,G - 1541\,i + 100.6 \quad (4)$$

The total of the percentages of the inert gases as shown in Table 1, is 6.1 per cent. or expressed decimally, 0.061. Substituting this in equation (4),

$$H = 1440\,G + 6.6 \quad (5)$$

Applying equation (5) to the average gas, as given by Table 1, in which the specific gravity is 0.6135, it would indicate a heat value of 890 B.t.u. The heat value as computed from analysis was 887.3, thus showing the approximation to be very close.

*By "dry" gas is meant that coming from a well producing gas exclusively as distinguished from that coming from an oil well, which is called "wet" gas. These terms have no reference to water vapor in the gas but imply the absence or presence of vapors of hydrogen higher in their respective series than those under consideration.

Some Exhaust Troubles

By James H. Beattie

Brooks is a gas-engine trouble man so much engrossed in the subject that the mere sound of the exhaust is sufficient to start him in its direction. He even claims that he can generally tell an engine's make from its exhaust.

Not long ago we were traveling together and had stopped for the night at a small country hotel. After supper we were sitting in front of the hotel when we heard what appeared to be the exhaust of a good-sized engine some distance away.

"Hello! that sounds like a B—— engine. I can tell them anywhere by the peculiar noise of the exhaust. Let us go over and see it," said Brooks.

"You know," he remarked, as we went along, "the B—— people use a peculiar type of hit-and-miss governor on their engines, and while they are all right for some purposes, the speed is so variable that they are wholly unsuited for work requiring close speed regulation. Notice from the sound of the exhaust that this engine takes five or six impulses, then cuts out almost as many. I'll venture that the speed of that engine is fluctuating 10 per cent."

From the sound we judged we were now close to the object of our search. "I guess it is in this yard," said Brooks; "just let me take a look over this board fence and I will see how we are to get in there." Brooks jumped up, and after

looking for a moment he got down with a rather foolish expression on his face.

"Well, how do we get in there?"

"I guess we don't want to get in," he replied.

I looked over the fence—and saw a husky darky industriously beating a carpet on a line. Every five or ten strokes he would change the beater from one hand to the other, and incidentally take a short rest.

After we had returned to the hotel Brooks told me several incidents about gas-engine exhausts and exhaust pipes, which led me to think that the exhaust of the internal-combustion engine is more important than most people believe.

"Last summer," began Brooks, "I was sent to a large summer resort where three of our vertical engines had been installed, to remedy some trouble with the exhaust valves burning and warping. The engines were of the three-cylinder type and the valves were not water-cooled. I found that they had connected the exhaust pipes of the three engines to a common header running the length of the engine room, then turning down the wall and passing through it into a muffling chamber outside the building. The header was large enough to carry the gases from all the engines, but it was only 3 ft. from the tops of the cylinders. The individual exhaust pipes from each cylinder were connected into the header with tees." Brooks then made the sketch, Fig. 1, to illustrate the arrangement.

He went on to explain that all the trouble was due to this arrangement of the exhaust pipes. The engines were of

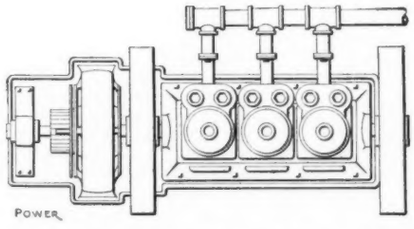


FIG. 1. PLAN VIEW SHOWING EXHAUST PIPE

100 hp. each and a large amount of hot gas passed out through the exhaust pipes. The flame was turned back by the tee on the header, and the trouble with the exhaust valves resulted. By rearranging the exhaust piping so that each engine had a separate exhaust header and that there were no sharp bends in the exhaust pipe, the trouble disappeared.

"In another case the trouble was due to another cause," continued Brooks. "The engine was small and had been installed by the purchaser to run a small mill. It operated all right for a time, then suddenly refused to carry its load. The engineer knew little about gas engines and was puzzled. I was sent from the factory to correct matters and found the engine apparently in good condition. The batteries were new and tested out all right; the ignition was properly timed, in fact, everything about the engine seemed to be in good condition, yet it would not develop enough power to run at normal speed even without a load.

"After close examination the trouble proved to be in the exhaust pipe. The engine was fitted with an exhaust chamber set on the floor near the engine, and the pipe from the engine should have entered the top of this chamber through a stuffing-box packed with asbestos. Instead, the man who had connected up

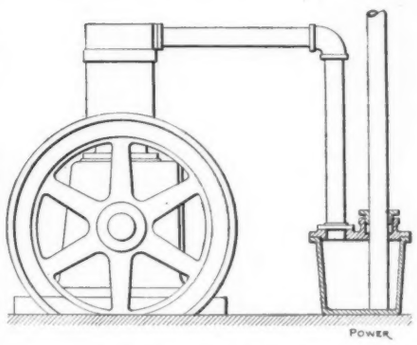


FIG. 2. OUTLET PIPE OF MUFFLER RESTING ON BOTTOM OF THE VESSEL

the pipes had reversed the connections so that the pipe from the engine was attached to the exhaust chamber by a flange and capscrews, and the pipe running through the roof was placed in the stuffing-box (Fig. 2).

"As a result, the weight of the long pipe through the roof had caused it to slide down until the end rested on the bottom of the vessel, leaving practically no exit for the exhaust gases."

One more incident related by Brooks showed the importance of the exhaust pipe. A shingle factory in Florida installed a 70-hp. single-cylinder engine several months ago. Not wishing to be annoyed by the noise of the exhaust, the superintendent had a muffling-box constructed outside the engine room. It was built of concrete and the 4-in. exhaust pipe was set solidly into it. As a result the expansion of the pipe sprung the studs holding the exhaust-valve casing, making it impossible to keep the packing from blowing out. They had continual trouble until the exhaust pipe was provided with a swing joint so that the pipe could expand and contract freely.

Comparative Costs with Producer Gas and Diesel Engine Plants

In a paper on power-plant operation delivered recently before the Dallas (Texas) chapter, N. A. S. E., Prof. A. C. Scott gave some interesting figures showing the comparative production costs between a 250-hp. Diesel engine plant operating in southwestern Texas and a 500-hp. producer-gas plant operating on Texas lignite 24 hours a day under a load factor of about 80 per cent. The comparative figures were as follows:

225-HP. DIESEL ENGINE PLANT, 700,000 KW.-HR.

Investment		
Engine, compressor, piping, etc., installed (A)		$15,800
Generator, switchboard and wiring (B)		3,500
Building, cooling tower and tanks (C)		3,000
Total		$22,300
Fixed charges		
Interest at 6 per cent		$1,338
Insurance and taxes at 2 per cent		446
Amortization (A) at 4 per cent		632
Amortization (B) at 2 per cent		70
Amortization (C) at 1 per cent		30
Profit at 5 per cent. on the investment		1,115
Total		$3,631
Operating costs		
Crude oil, 1680 bbl. at $1.22 per barrel	$2,050	
Lubricating oil and waste	250	
Water	250	
Engineers	2,000	
Repairs	250	
Total		$4,800
Total costs for 700,000 kw.-hr.		$8,431
Cost per kilowatt-hour	$0.012	

500-HP. PRODUCER GAS PLANT, 2,000,000 KW.-HR.

Investment		
Producers (A)	$13,600	
Engine (B)	22,400	
Generator, switchboard, wiring, cooling tower (C)	10,600	
Building (D)	3,400	
	$50,000	
Fixed charges		
Interest at 6 per cent. on $50,000	$3,000	
Insurance and taxes at 2 per cent	1,000	
Amortization (A) and (B), 4½ per cent	1,620	
Amortization (C), 2 per cent	212	
Amortization (D), 1 per cent	34	
Profit at 5 per cent. on investment	2,500	
		$8,366
Operating costs		
Lignite, 3.7 lb. per kw.-hr., 3700 tons at $1.50	$5,550	
Lignite, standby losses, 300 tons at $1.50	450	
Engineers	3,300	
Producer men	3,000	
Oil and waste	350	
Water	160	
Repairs	250	
		$13,060
Total costs for 2,000,000 kw.-hr.		$21,426
Cost per kw.-hr.		$0.0102

It will be noted that if the load factor of the Diesel plant were increased to correspond with that of the producer-gas plant the kilowatt-hours delivered would be about 900,000 per year and the oil consumption approximately 1837 bbl. With the other operating costs as stated and the same fixed charges, this would make a total of $8621, or $0.0096 per kilowatt-hour.

[It would seem that Prof. Scott has assumed the amortization charges entirely too low.—EDITOR.]

"With the crank of an engine at half stroke, where is the piston?" said the examiner.

"Where the h——l would it be but in the cylinder?" the candidate retorted.

Refrigeration Department

Principles and operation of ice-making and refrigerating plant and machinery

Does Large Artificial Ice Storage Pay?

By R. P. Kehoe

This question is often raised and the following basis of calculation may assist those interested. The principal reason for considering large storage arises from the fact that the time of full production each year is limited; that is, the yearly load factor is low. This is true everywhere, except in very warm climates, and greatly influences the possible annual profit.

A large ice storage makes possible operating at full capacity throughout the year, but the storage building means a large additional investment and a maintenance expense that must be taken into account.

As an example, in a plant of 100 tons daily capacity, operated in the usual manner, an average yearly load factor of 50 per cent. is a safe basis; the full yearly capacity figured for 360 days being 36,000 tons. With a 50 per cent. load factor the actual yearly output would be 18,000 tons, this amount being distributed over the 12 months. The demand during the three hottest months would be the full capacity of 100 tons a day, dwindling down to a very small amount in the winter months.

It is assumed that such a plant is located where there is sufficient market for the full capacity in the summer months, which is only about three months or less, and must determine the size of the plant.

A plant of 60 tons daily capacity in conjunction with a large ice storage, may be made to take care of the same demand supplied by a 100-ton plant conducted in the usual manner. Table 1 indicates an average monthly production throughout the year in a 100-ton plant and how a 60-ton plant can be made to fill the same requirements.

The demand in various localities will differ and the monthly requirements may not correspond with the average figures which have been taken, but the relation between summer and winter production will in most cases be practically the same. Full capacity can be maintained during the fall and early winter in order to shut down the plant for a month or more for a thorough overhauling and to install repair parts and improvements. The small amount of ice in storage will probably not need refrigeration, as the outside temperature will be comparatively low at this time. If absolutely essential, a small auxiliary refrigerating machine can be included in the equipment to maintain the storage when the main unit is shut down for repairs. This auxiliary unit may be operated by motor or other available power, but in all probability it will not be required.

The last column indicates a proposed schedule of operation for the 60-ton plant to produce a yearly output of 18,000 tons and meet the same demand as a 100-ton plant. The full capacity is maintained for ten months, leaving two months for overhauling, improvements, etc. The excess amount produced in October and November will supply the demand in December and January. Only about 1350 tons are in storage when the plant is shut down, this small amount losing only a slight percentage from melting during the cold season.

Since the ice-making machine must be large enough to care for the entire storage and manufacture at full capacity in the summer months, the normal capacity will be exceeded in the cooler seasons. This is especially true when little or no ice is stored. The schedule of operation does not take this into consideration and some leeway is therefore represented.

To arrange a plant to operate at full load for 10 months instead of six is good business practice if the increase in cost of operation, depreciation and investment is not too great. The additional cost is not large, being confined to the extra fuel required for supplying the refrigeration to maintain the ice storage. Depreciation will also increase to some extent, but the most important item is the cost of the storage building. This really seems to decide the question, for if the first investment is increased too much, it would be better to build a 100-ton plant with only the usual daily storage.

The most favorable conditions for large storage are obviously a low yearly load factor and cheap building materials. The cost of brick buildings in large cities would be very unfavorable and the load factor high. Under these circumstances the machinery is idle only a short time each year and there is no crying need to spread the production over a greater length of time. The calculations are therefore based on a wood structure with inexpensive insulation and a 50 per cent. yearly load factor. Tables 2 and 3 show how a proper comparison may be made.

TABLE 2. 100-TON ICE-MAKING PLANT—SIMPLE CAN SYSTEM

Investment	
Complete mechanical equipment	$54,000
Building and foundations	30,000
Total investment	$84,000
Daily Operating Expense	
16 tons of coal at $3.50	$56.00
One chief engineer	5.00
One night engineer	3.50
Two firemen at $2	4.00
Four tankmen at $2	8.00
Two laborers or storehousemen at $2	4.00
Two oilers at $2	4.00
Ammonia, oil, waste and supplies, etc.	10.00
Office man	4.00
	$98.50
Depreciation, etc.	
5% depreciation on machinery ($54,000)	$2,700.00
2% depreciation on building, etc. ($30,000)	600.00
Repairs, taxes, water and incidentals (5%)	4,200.00
	$7,500.00
Summary	
180 days' full operation at $98.50	$17,730.00
Labor for balance of year, leaving out only two laborers = 180 days at $28.50	4,845.00
Depreciation, etc.	7,500.00
	$30,075.00
Income from sale of 18,000 tons of ice at $2.50	45,000.00
Profit.....$45,000 — $30,075 = $14,925 = 17.8%	

A storage space large enough for 5000 tons of ice has been figured to be safe and give ample room for handling the

TABLE 1. 60-TON PLANT AND STORAGE DOING WORK OF 100-TON PLANT

Month	Approx. Average Output in Tons of 100-Ton Plant to Supply Usual Demand		With 60-Ton Plant Excess Which Must be Supplied from Storage	Proposed Time of Production for Storage Purposes	Proposed Schedule of 60-Ton Plant to Meet Usual Demand of 100-Ton Plant
	Daily	Monthly	Monthly	Monthly	Monthly
January	15	450	....	150	...*
February	10	300	....	1500	1800
March	25	750	....	1050	1800
April	25	750	....	1050	1800
May	50	1500	....	300	1800
June	100	3000	1200	....	1800
July	100	3000	1200	....	1800
August	100	3000	1200	....	1800
September	75	2250	450	....	1800
October	50	1500	....	....	1800
November	25	750	....	....	1800
December	25	750	....	....	...*
Totals		18,000	4050	4050	18,000

*Overhauling and repairs.

ice; 50 cu.ft. per ton should be quite sufficient. This space could be about 200 ft. long by 100 ft. wide and 12½ ft. high, and the total wall, floor and ceiling surfaces aggregate 47,500 sq.ft. A heat leakage of 5 B.t.u. per square foot per degree difference in temperature every 24 hours is a conservative estimate, and the refrigerating work would be

$$\frac{47{,}500 \times 5 \times 50}{288{,}000} = 40 \text{ tons}$$

The average temperature difference between the outside and the interior of the storage has been estimated as 50. Calculating that each square foot of pipe surface will absorb 50 B.t.u. per degree difference in temperature every 24 hours and assuming a back pressure of 15 lb. equivalent to an ammonia temperature of 0 deg. F. (equals a temperature difference of about 30 deg.), the amount of 2-in. piping required for the storage would be

$$\frac{47{,}500 \times 5 \times 50 \times 1.6}{30 \times 50} = 12{,}667 \text{ ft.}$$

or in even numbers 12,600 ft. The approximate cost of this piping would be $5000 erected in place.

The depreciation, repairs, etc., have been increased in the 60-ton plant to 6 per cent. as compared with 5 per cent. in the 100-ton plant. This is quite fair since the apparatus will have to run 66⅔ per cent. more of the time each year.

Notwithstanding that the 60-ton plant has been favored as much as possible, the yearly profit is $1000 less and the percentage of earnings to investment is very little more. If the cost of the storage building should be somewhat higher, the 100-ton plant would make a still better showing. The figures indicate how important it is to study each situation carefully to determine the best combination. Exact estimates should always be procured covering equipment and buildings, and if the same method is followed no difficulty will be had in obtaining the correct solution.

It is sometimes claimed that a plate ice plant is best because artificial ice produced by this method can be safely stored without refrigeration. Plate ice undoubtedly will look better than can ice when stored for any length of time without refrigeration, and it is very difficult to keep the latter from freezing together because the cakes are so even, but it is doubtful if it pays to thus store manufactured ice. The writer has never seen any accurate figures showing percentage of meltage and cost of refrigerating a storage; the latter can be estimated, but it is almost impossible to calculate the former.

It can be asserted that a plate plant and large ice storage will show a good profit, not so much on saving the expense of refrigerating the storage, but by virtue of the higher economy which is taken advantage of throughout almost the entire year. Using the same method as the former tabulations, the plate plant is figured out in Table 4.

TABLE 3. 60-TON ICE-MAKING PLANT—SIMPLE CAN SYSTEM

(With 5000 tons ice storage)

Investment	
Complete mechanical equipment	$40,000
Building and foundations	35,000
Total investment	$75,000
Daily Operating Expense	
(For 60 tons ice production)	
10 tons of coal at $3.50	$35.00
One chief engineer	5.00
One night engineer	3.50
Two firemen at $2	4.00
Two tankmen at $2	4.00
Two laborers or storehousemen at $2	4.00
Ammonia, oil, waste and supplies, etc.	7.50
Office man	4.00
	$67.00
Ice Storage	
Entire refrigerating work = 40 tons, requiring 3 tons of coal at $3.50	$10.50
Depreciation, etc.	
6% depreciation on machinery ($40,000)	$2,400.00
2% depreciation on building, etc. ($35,000)	700.00
Repairs, taxes, water and incidentals (6%)	4,500.00
	$7,600.00
Summary	
10 months' full operation, 300 days at $67.00	$20,100.00
Carrying full ice storage for about 6 months, 180 days at $10.50	1,890.00
All labor during two months' shutdown, 60 days at $24.50	1,470.00
Depreciation, etc.	7,600.00
	$31,060.00
Income from sale of 18,000 tons of ice at $2.50	45,000.00
Profit.....$45,000 — $31,060 = $13,940 = 18.6%	

TABLE 4. 60-TON ICE-MAKING PLANT—PLATE SYSTEM

(Compound condensing steam engine. 5000 tons ice storage)	
Complete mechanical equipment	$60,000.00
Building and foundations	40,000.00
	$100,000.00
Daily operating expense	
(For 60 tons ice production)	
5 tons of coal at $3.50	$17.50
One chief engineer	5.00
One night engineer	3.50
Two firemen at $2	4.00
Two harvesters at $2	4.00
Ammonia, oil, waste, supplies, etc.	7.50
	$41.50
Depreciation, etc.	
6% depreciation on machinery ($60,000)	$3,600.00
2% depreciation on building ($40,000)	800.00
Repairs, taxes, water and incidentals (6%)	6,000.00
	$10,400.00
Summary	
10 months' full operation, 300 days at $41.50	$12,450.00
All labor during two months' shutdown, 60 days at $16.50	990.00
Depreciation	10,400.00
	$23,840.00
Income from sale of 17,000 tons of ice (assuming loss of 1000 tons through meltage) at $2.50	42,500.00
Profit.....$42,500 — $23,840 = $18,660 = 18.66%	

Table 5 gives a summary of the three tabulations, which will be of assistance in making a comparison.

The only conclusion which can be drawn from these figures is that there is very little difference between the three propositions as an investment, and a careful and accurate estimate must be made in every instance to determine which plant will prove the best.

Trouble from Frost

A correspondent recently asked the question printed below, and the reply following may be of interest to engineers experiencing similar trouble.

Of two vertical, single-acting inclosed crank-case ammonia compressors, one gives trouble by frosting all over the base of the crank case and the water jacket, while the other does not frost at all. A ¾-in. line with a valve connects the base of the compressor which frosts to the suction line. The valve is left open to prevent the accumulation of pressure in the crank case from forcing the oil out through the shaft stuffing-box. If the box is turned tight enough to prevent this it heats. The frost melts off when the valve is closed. What causes the trouble; does the high-pressure gas get by the piston into the base?

It would appear that liquid ammonia is entering the base of the frosting compressor through the line connecting the base to the suction line. This would rarely happen if the connection is made into the bottom of the line and the system is so operated that the suction line frosts back heavily at the point where the connection is made. A small amount of liquid ammonia is sufficient to frost the base of a machine for a long time as the absorption of heat through the heavy cast-iron walls is slow and the coating of frost offers still further resistance.

The necessity of running with the valve in the connecting line open is probably due to leakage of the high-pressure gas past the piston into the base. A new set of piston rings carefully fitted will probably remedy the trouble.

If the other compressor cannot be made to frost it may be due to the suction line to this compressor offering more resistance to the passage of the return gas. If the stuffing-box continues to heat after the piston has been made tight, insert behind the last ring of packing a thin split ring made of cast iron with a groove turned on the inside to form a small

TABLE 5. SUMMARY OF COST FIGURES

	Investment	Daily Operating Expense	Total Yearly Expense	Estimated Profit	Percentage of Profit to Investment
100-ton can ice-making plant	$84,000	$98.50	$30,075	$14,925	17.8
60-ton can ice-making plant and 5000 tons ice storage, refrigerated	75,000	67.00	31,060	13,940	18.6
60-ton plate ice-making plant and 5000 tons ice storage, not refrigerated	100,000	41.50	23,840	18,660	18.66

oil pocket or miniature "lantern." Make the bore of the ring just large enough so as not to score the shaft. The ring should make a snug fit on the inside of the stuffing-box.

Measurement of Frigorific Power*

Countries using the metric system express the power of a refrigerating machine by the number of frigories which that machine can produce in one hour, under given conditions of evaporation and of condensation. The power of machines is also often expressed by the number of kilograms of ice they are able to manufacture in the course of one hour's work.

English-speaking countries express the power of machines by frigorific tons per 24 hours; that unit measures the quantity of refrigeration necessary to freeze one ton of water without changing its temperature; that is, the water being taken and frozen at 0 deg. C. However, the British or long ton being somewhat different from the American or short ton, the result is that units of power in the two countries are not alike.

The United States also uses another unit: the efficiency of machines is sometimes estimated in gallons-degrees per minute, a unit measuring the quantity of refrigeration necessary to lower by 1 deg. F. the temperature of 1 gal. of water taken at 33 deg. F.

The concordance between these various units is shown in the accompanying table.

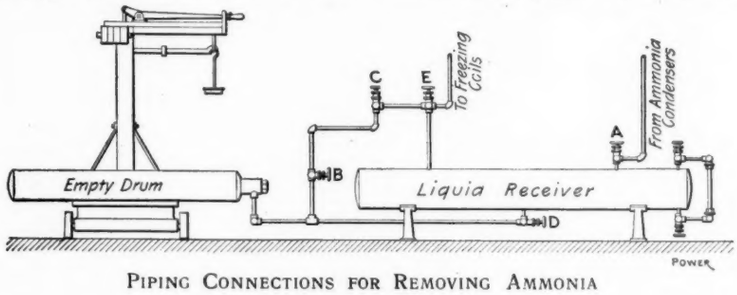
*From bulletin of the International Association of Refrigeration.

MEASUREMENT OF THE POWER OF A REFRIGERATING MACHINE ACCORDING TO THE VARIOUS SYSTEMS

Frigories-hour	British Frigorific, Ton per 24 hr.	American Frigorific, Ton per 24 hr.	Gallons-Degrees per minute
100	0.030	0.033	0.907
200	0.059	0.066	1.814
300	0.089	0.099	2.721
400	0.118	0.132	3.628
500	0.148	0.165	4.535
600	0.177	0.198	5.442
700	0.207	0.231	6.349
800	0.236	0.264	7.256
900	0.266	0.298	8.163
1,000	0.295	0.331	9.070
2,000	0.590	0.661	18.014
3,000	0.886	0.992	28.21
4,000	1.181	1.324	36.28
5,000	1.476	1.655	45.35
6,000	1.772	1.986	54.42
7,000	2.067	2.314	63.49
8,000	2.362	2.647	72.56
9,000	2.657	2.975	81.63
10,000	2.959	3.306	90.70
12,000	3.549	3.972	108.84
15,000	4.428	4.961	136.05
18,000	5.314	5.950	163.26
20,000	5.904	6.612	181.4
25,000	7.380	8.275	226.7
30,000	8.856	9.917	272.1
35,000	10.34	11.57	317.5
40,000	11.81	13.24	362.8
45,000	13.29	14.90	408.2
50,000	14.76	16.55	453.0
55,000	16.24	18.19	499.0
60,000	17.72	19.86	544.0
65,000	19.19	21.49	590.0
70,000	20.67	23.13	635.0
75,000	22.14	24.80	680
80,000	23.62	26.47	726
85,000	25.09	27.73	771
90,000	26.57	29.76	816
95,000	28.05	31.42	862
100,000	29.52	33.06	907
110,000	32.47	36.37	998
120,000	35.43	39.72	1,088
130,000	38.38	42.98	1,179
140,000	41.33	46.26	1,290
150,000	44.28	49.59	1,361
160,000	47.23	52.93	1,452
170,000	50.18	55.46	1,542
180,000	53.13	59.50	1,632
190,000	56.09	62.84	1,723
200,000	59.04	66.11	1,814
210,000	61.99	69.43	1,905
220,000	64.94	72.74	1,996
230,000	67.89	76.05	2,086
240,000	70.85	79.44	2,176
250,000	73.80	82.64	2,267
260,000	76.75	85.96	2,357
270,000	79.70	89.27	2,448
280,000	82.66	92.52	2,540
290,000	85.61	95.85	2,630
300,000	88.56	99.18	2,722
400,000	118.08	132.22	3,628
500,000	147.60	165.28	4,534
1,000,000	295.20	330.56	9,068
2,000,000	590.40	661.12	18,136
3,000,000	885.60	991.68	27,204
4,000,000	1,180.80	1,232.24	36,272
5,000,000	1,476.00	1,652.80	46,340

Drawing Ammonia from Compression System

In a recent issue of POWER, Mr. McGerry illustrates and describes a method of removing ammonia from the piping system of a compression-refrigerating or ice-making plant, and storing it in an empty drum. It is poor practice to attempt to remove liquid ammonia from the system connecting the empty drum to the highest point of the receiver; the proper place for such a connection is at the drain valve on the bottom of the receiver.



PIPING CONNECTIONS FOR REMOVING AMMONIA

As a rule, the liquid receiver is set high enough above the floor level to be over the inlet connection on the empty ammonia drum when it is placed on a pair of platform scales. In the sketch the empty drum is shown connected differently.

To remove the charge, operate the compressor slowly, allowing condensing water to circulate freely over the ammonia condenser. See that the inlet valve *A* on the ammonia receiver is open, allowing the liquid ammonia to flow from the ammonia condenser into the liquid receiver. Next open the valve on the empty ammonia drum, then open the drain valve *D* and let the liquid ammonia flow into the empty drum. The charging valve *C* should also be opened and when the line connecting the liquid receiver and empty drum becomes gas-bound, valve *B* on the line to the charging valve can be opened for an instant, allowing the compressor to relieve the gas-bound line.

In cases where there is no charging connection at the liquid receiver, the relief line may be carried to the ammonia suction line or left open to the atmosphere. In hotels or office buildings, the last mentioned plan could not be used, as ammonia cannot be permitted to escape to the open air.

It is understood, of course, that the outlet valve *E* on the liquid receiver is closed, the gas released at valve *B* passing above the seat of valve *E* and on through the line to either the freezing or direct-expansion coils, and finally back to the compressor, where it is again discharged to the condensers and condensed to liquid form.

It is important when filling empty drums to watch the scales closely so that the drums are not filled too full.

THOMAS BAKER.

New York City.

Wear in Ammonia Compressor Cylinder

I would like to have readers of POWER explain why a horizontal ammonia-compressor cylinder wears more at the top than on the bottom surface of the cylinder. For several years I have noticed in overhauling and reboring horizontal ammonia-compressor cylinders that the most wear seems to be on the top surface of the cylinder irrespective of the location of the suction or discharge valves. Some machines have suction valves on top and some have the discharge, but both develop the same peculiar wear in the cylinder.

C. E. ANDERSON.

Chicago, Ill.

Compressed Air from Ammonia Compressor

In our plant we have no air compressor and as we have a number of motors which require frequent cleaning as they are located in dirty places, we have been compressing the air for this purpose with the ammonia compressor. The ammonia was first worked out of the cylinder; the discharge valves were then closed and the purge valves opened. The suction-purge plugs were then removed and air under pressure turned on to the motors.

MARTIN MCGERRY.

Holley, N. Y.

Issued Weekly by the
Hill Publishing Company
JOHN A. HILL, Pres. ROB'T MCKEAN, Sec'y.
505 Pearl Street, New York.

Monadnock Bldg., Chicago.
6 Bouverie Street, London, E. C.
Unter den Linden 71—Berlin, N. W. 7.

FRED R. LOW, Editor.

Correspondence suitable for the columns of POWER solicited and paid for. Name and address of correspondents must be given—not necessarily for publication.

Subscription price $2 per year, in advance, to any post office in the United States or the possessions of the United States and Mexico. $3 to Canada. $5 to any other foreign country.

Pay no money to solicitors or agents unless they can show letters of authorization from this office.

Subscribers in Great Britain, Europe and the British Colonies in the Eastern Hemisphere may send their subscriptions to the London Office. Price 21 Shillings.

Entered as second class matter, December 20, 1910, at the post office at New York, New York, under the Act of March 3, 1879.

Cable address, "POWPUB," N. Y.
Business Telegraph Code.

CIRCULATION STATEMENT

Of this issue, 29,000 copies are printed.

None sent free regularly, no returns from news companies, no back numbers. Figures are live, net circulation.

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POWER

A New Analysis of Indicator Diagrams

An indicator diagram gives the pressure of steam with which the cylinder was filled at any point in the stroke. Knowing the volume of the cylinder up to the chosen point and the number of times it is filled per hour, it is easy to compute, if the point chosen is after cut-off takes place, the volume of steam of the indicated pressure passing through the engine per hour.

If the contents of the cylinder were all dry-saturated steam, the weight per cubic foot could be taken from the steam tables and the weight of steam used per hour determined, but a considerable quantity of water is present, caused by condensation upon the containing surfaces, and any determination based upon the assumption that the steam is dry saturated will be from fifteen to fifty per cent. in error.

As the pressure is lowered by expansion a portion of the water is evaporated so that the expansion line, instead of falling off as rapidly as it would if only a constant weight of steam were acting, is kept up until the curve resembles the isothermal or constant temperature curve of a perfect gas.

It is natural to suppose that the form of the curve would be influenced by the amount of heated water present at the commencement of expansion, and Paul J. Clayton, of the engineering-experimental station of the University of Illinois, in a remarkable paper presented to the American Society of Mechanical Engineers and abstracted on page 858, shows that this is so. A large number of indicator diagrams were replotted upon logarithmically ruled paper, and unless the conditions under which they were taken were abnormal, the expansion and compression curves became straight lines, but with different inclinations for different diagrams.

The most significant fact brought out by Mr. Clayton is that there is a definite relation between the inclination of the expansion curve so plotted and the quality of the steam; that is, the amount of moisture present at the commencement of expansion.

If this relation can be determined with precision, the engineer will have at his command an easy way to determine, with just the same degree of precision, the water rate of his engine simply by taking a diagram from it. An engine, instead of having its performance determined once in its lifetime by a laborious and expensive test, can be kept under constant surveillance, any increase in its steam consumption detected and the cause removed. The size of the engine appears to have little effect upon this relation; speed has some effect and pressure more.

Mr. Clayton has evolved such a statement of the relation as to enable one to calculate the water rate for the ordinary case with an average difference of some four per cent. between the calculated results and those obtained by weighing the exhaust. It is likely that the analysis of a larger number of diagrams and a study of the conditions under which they were taken will result in a formula or set of diagrams which will give still more accurate results for a case of which all the conditions are known, and the greatest service which an engineer who has access to diagrams taken while the water rate was being measured can perform for steam engineering is to either plot these diagrams himself or send them to Mr. Clayton or to POWER with a complete statement of the significant conditions.

Besides determining the water rate, the new method of analysis indicates much more positively than does the original diagram, leakage into or out of the cylinder and affords means of definitely determining the clearance. It is applicable to diagrams from internal-combustion engines, air and ammonia compressors, etc., as well as to those from the steam engine.

We heartily recommend the reading of the abstract on page 858 and urge the reader to try the analysis in his own practice and report results. Logarithmically ruled paper may be obtained from any dealer in draftsman's supplies and

copies of the complete paper may be had upon application to the secretary of the American Society of Mechanical Engineers, 29 West Thirty-ninth St., New York.

Prof. Clayton has shown that by replotting an indicator diagram upon logarithmically ruled paper a number of points are brought out that the original diagram fails to show. It remains now for somebody to invent a logarithmic reducing motion and pencil movement so that one can take the logarithmic diagrams right from the cylinder and proceed to analyze without all the trouble of replotting.

Depreciation and Obsolescence

A steam plant uses up something besides coal and oil and waste and water. It uses up boilers and engines and pumps and apparatus. When, therefore, one computes the cost of making power he must take into account not only the fuel and water and wages and small supplies but the plant which is being used up and is depreciating in value from year to year.

From the point of view of reconvertibility into hard cash a large depreciation takes place at the start. An engine which has been run ever so little cannot be sold for anything like what it cost set up and ready to run. But it is usual to assume that the business will continue throughout the life of the engine and to charge each year's expenses with an equal proportion of its cost. Supposing a plant will last twenty years there would be added to the actual current expenditures of each year one-twentieth, or five per cent. of the cost of the plant in making up the cost of power production. This is depreciation. The amount thus reserved from the profits is, theoretically at least, set aside for the purchase of new apparatus as the old is used up. The amount thus set aside from year to year is capable of earning interest, and if credited with compound interest, a considerably less percentage need be charged off each year.

The purpose of the account is likely to make a difference in the method of handling this item. A public-service corporation should not be allowed to use it as a means of swelling the cost for purposes of rate fixing, and then not apply it to its avowed purpose. If at the end of the usefulness of the plant the capital or investment fund upon which interest and profits are to be earned is credited with the investment for the new it should be charged with what has been collected for depreciation upon the old.

But it may happen that long before the machinery is worn out it may be rendered obsolete by the invention or development of something which is so much better that its owner cannot afford to continue to use it. This obsolescence or the likelihood of it should not be allowed to be mixed up with depreciation. The old plant will make good on the basis of the original estimate. It will cost no more to run it than it was expected that it would because there has been something found later which will run more economically. The new thing must be so much better that it will pay for the sacrifice, the obsolescence, of the old. In case it will do this the investment account should be credited with the amount invested in the new machinery and charged with the depreciation already collected upon that which it displaces together with whatever the old may bring if disposed of. This will leave the uncollected portion of the original cost of the old apparatus in the capital or investment account to go on collecting depreciation until the original cost of the old apparatus has been wiped out, when it should cease so far as that investment is concerned.

Action between Ash and Firebrick

E. G. Bailey, combustion engineer, of Boston, brought out a point in a recent lecture to the Institute of Operating Engineers in New York. The trend of boiler practice has been in the direction of getting greater evaporation from a given amount of heating surface. The old idea that economy lay in large ratios of heating to grate surface, in having a lot of water-cooled surface to absorb the heat from the gases, in burning coal at moderate rates of combustion has been discounted by engineers who had to run their boilers for all that there was in them to get over a peak, and who found that the loss of efficiency when running under these forced conditions was surprisingly small.

It develops that, whether or not it pays to run boilers at considerably over 3 pounds of evaporation per square foot of grate surface with deliberate intent and as a regular practice, it is cheaper to double this rate during the few hours of excessive demand than to keep a large reserve of extra boilers with banked fires standing the greater part of the time for use only under peak-load conditions. Furthermore, it has been found that a better control of furnace conditions is possible with a lively rate of combustion than when the fire is simply allowed to mull and the boiler to stew.

The limit to progress in this direction has been set not by the capacity of the boiler to absorb the heat, but by the ability of the furnace to stand it. It is a question of how much firebrick one can afford to burn; how often he can afford to replace furnace walls and arches. The country has been scoured for furnace material which will stay put with these high rates of combustion.

Mr. Bailey has previously called attention forcibly to the important relation of the fusing point of the ash to the clinkering properties of the coal. Clinker is simply melted ash. An ash which melts at a low temperature will clinker easily and have a more prejudicial effect upon the actual practical value of the coal than a much larger percentage of ash which will not fuse but will work itself out of the fire in the powdery form and allow the firing to go on uninterruptedly and with infrequent cleaning.

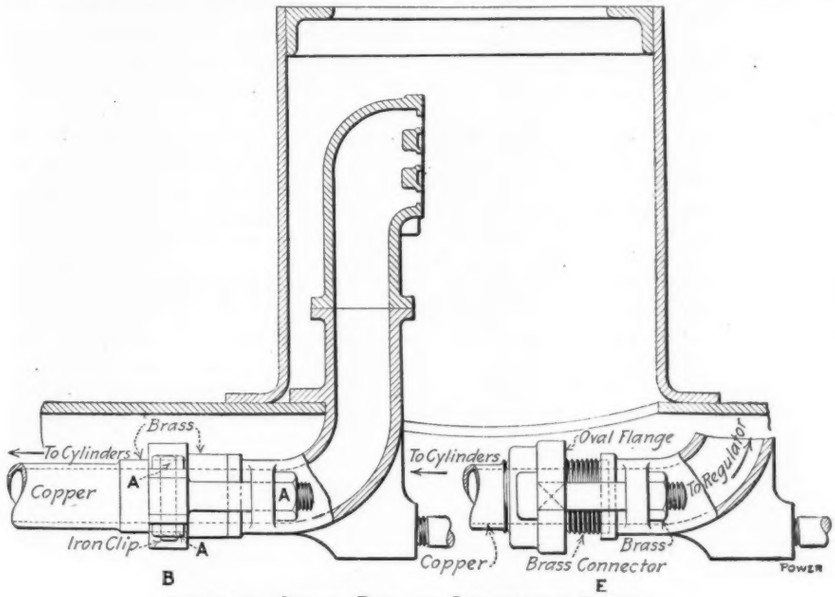
He now shows that the chemical constitution of the ash has an important influence upon the fusibility of the firebrick. Certain constituents of ash act upon certain clays in the same way that the flux put into a cupola for the purpose reduces the fusibility of its contents. In one case, for instance, where they were having trouble with the furnace linings, the fusing temperature of the firebrick was found to be 3100 degrees and that of the ash 2600 degrees, but combined they fused at 2400 degrees. The ash from other coals would not have produced this effect upon this particular brick, and other brick might have been used with this same ash without having its melting point so materially affected. It would seem as though there were an interesting line of investigation here, which promises to have an important bearing upon a power-plant problem of very pressing interest.

Readers with Something to Say

A letter good enough to print will be paid for. Ideas, not mere words, wanted

Internal Steam Pipe Design

The usual design of internal steam pipes on locomotive boilers is shown at *B* in the illustration. The removal or repair of such pipes when broken as shown is very difficult, especially when the tubes are in the boiler. The nuts *A* are generally rusted fast to the ring and have to be split before they can be removed.



INTERNAL STEAM PIPE OF LOCOMOTIVE BOILER

To avoid such trouble I designed the arrangement shown at *E*. A cast-iron oval flange with a copper screw connector is used to avoid the action of rust. The clip bolts are done away with and long bolts used instead. The nuts are brass and easy to remove.

A. L. HAAS.

London, England.

Why Did the Blowoff Pipe Get Red Hot?

In a lumber mill steam is furnished by a new horizontal return-tubular boiler 6½x18 ft.; the fuel is sawdust. The boiler was ordered in commission but the cast-iron protection sleeve for the blowoff pipe had not arrived. As there were no firebricks to protect the blowoff pipe, the chief placed a piece of old steel rail in front of it so as to break at least part of the flames.

Everything went well for about two hours, when the chief suddenly startled me, saying: "The blowoff is red hot!" We at once reduced the steam pressure to 40 lb. and carefully opened the blowoff valve. After a little spitting the water appeared, carrying before it a powdery substance. As soon as the water began to flow, the pipe cooled off. The chief then partially closed the valve to permit a small amount of water to run through all the time, thus keeping the pipe cool. The pressure was again raised and everything going in less than 20 minutes.

How did the pipe get red hot, if it was full of water? Will some reader inform me the best way to draw a sawdust fire?

PAUL HANNEMANN.

Passadumkeag, Maine.

Corliss Engine Diagrams

The diagrams in Figs. 1 and 2 were taken from an old crab-claw single-eccentric Corliss engine; Fig. 1 was taken under normal running conditions, and Fig. 2 with a back pressure of 12 lb. added to the normal conditions.

Fig. 2 is peculiar in that it was taken from a single-eccentric engine with lap on the steam valves, and the eccentric set at 90 deg. ahead of the crank. It seems to me that cutoff should have occurred at one-half stroke. I believe that, due to the additional load, the engine attempted to hold the cutoff until the end of the stroke, but because of dull toes on the crab-claw it fell off at this point, but why it should cut off just when the mean effective pressure equaled that of Fig. 1, I should like explained.

Fig. 3 was taken from a modern Corliss engine. I tied up the catch block

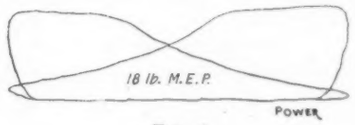


FIG. 1

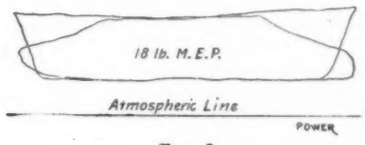


FIG. 2

on one end so that the other would have to do all the work. The result shown by the dotted line is a mean effective pressure of 42 lb., the total of that of both the head and crank ends.

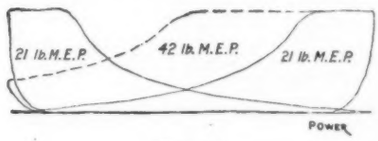


FIG. 3

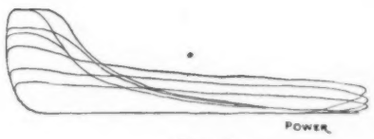


FIG. 4

Fig. 4 shows a card taken from the above engine while starting and until normal speed and cutoff were reached.

A. C. WALDRON.

Revere, Mass.

Silencing a Noisy Valve Gear

Recently a friend requested that I suggest a cure for a noisy valve-gear on his Corliss engine. I found that the links were nicely adjusted, the leather cushions on the latches were of sufficient thickness, and I was about to pronounce the gear in excellent condition when he informed me that when running the valve stems moved vertically for quite a perceptible distance.

Further examination showed that the hubs of the brackets were considerably worn, and that the valve stems were worn flat on the top and bottom; the oil holes leading to the stem were also plugged solid.

We turned down the stems to round

them properly. As there was plenty of stock in the bracket we bored it larger by ⅜ in., after which we cut a slot for its entire length. A piece of shafting a trifle smaller than the valve stem was then centered in it, after which babbitt metal was poured into the circular space. The hole was then bored to the required size and the oil holes drilled out. A groove connecting the holes was then made and the parts reassembled. The engine now runs smoothly and without noise.

LEIGHTON JOHNSON.

Exeter, N. H.

Comment on These Diagrams

The indicator diagram, Fig. 1, was taken from the high-pressure cylinder of a 24 and 34 by 48-in. cross-compound condensing Corliss engine running under at 60 r.p.m., and belted to a 500-ton refrigerating machine. Fig. 2 was taken from the low-pressure cylinder. The boiler pressure was 145 lb., receiver pressure 20 lb. and 24 in. of vacuum obtained while taking the diagrams.

Figs. 3 and 4 were taken from the low-pressure cylinder of a tandem-compound noncondensing engine, running under at 90 r.p.m. Fig. 5 was taken from the 24x48-in. steam cylinder of an air compressor, with the air cylinder tandem-coupled to the steam cylinder. The engine is noncondensing, using steam at 150 lb. and running at 50 r.p.m. Fig. 6 was taken from the air cylinder of the above engine, the air pressure being 75 lb. Will interested readers comment on these diagrams?

C. E. ANDERSON.

Chicago, Ill.

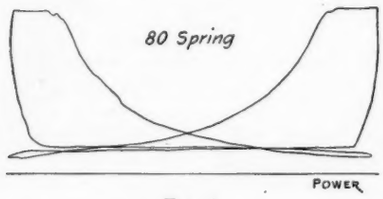


FIG. 1

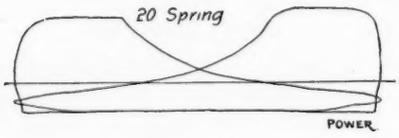


FIG. 2

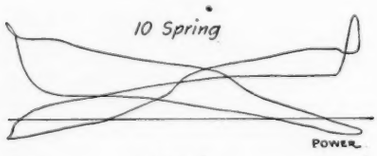


FIG. 3

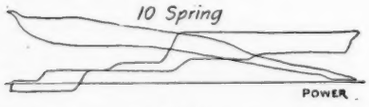


FIG. 4

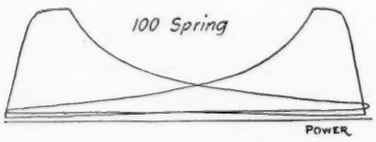


FIG. 5

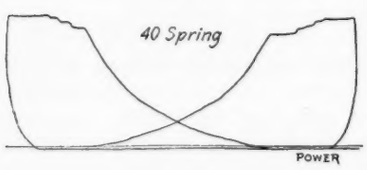


FIG. 6

AIR CYLINDER DIAGRAM

Taking Steam from Water Column Connections

Fig. 1 illustrates the water column and connections as found in a certain plant. They are made with 1¼-in. pipe and valves, but a reducing tee was used in the upper connection. A ¾-in. outlet is thus provided, which branches in two directions. One of them is connected to the damper regulator, and as steam is not drawn through it no harm is done, but the principle is wrong. The other supplies a machine that takes enough to reduce pressure in the 1¼-in. connection; hence when only a partial load is carried, the water in the gage-glass rises and falls, proving that the indication is not reliable. On full load the water goes out of sight in the glass, and some of it mingles with the outgoing steam. This is not only dangerous, because it shows a false water-level, but very wet steam is supplied to operate the machine.

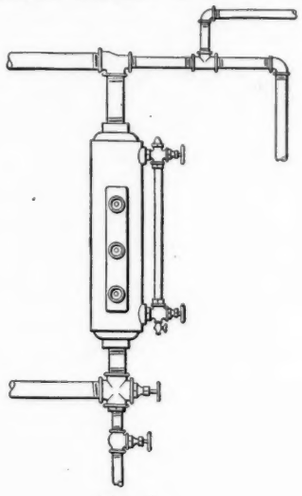


FIG. 1.

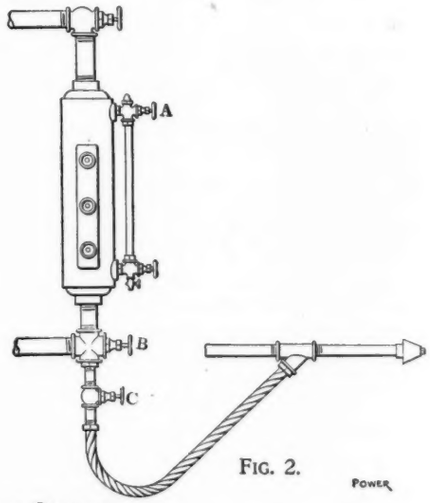


FIG. 2.

WATER COLUMN CONNECTIONS

Fig. 2 shows another water column with suitable connections. The engineer used the drip pipe to supply steam for the tube blower. Having connected it as shown, he opened *A*, closed *B* and opened *C*. After all water was drained from the column and pipes, dry steam was secured for cleaning the tubes. If this is done when the fire is banked, no special harm results, but where a boiler is not heavily loaded, it is practicable to clean the tubes while the engine is running rather than either before or after the regular working day. During this time it is impossible to know how much water is in the boiler, which is bad practice.

A safe rule is, never connect anything into water-column connections except the water column.

W. H. WAKEMAN.

New Haven, Conn.

Mismanaging Fires

The head fireman of a certain plant had an assistant who wanted to do things right, but the former would not let him; the assistant seemed the better man of the two. On a visit to the plant I found an opportunity to give him the advice an older man could give to a younger one. In a short while the assistant fireman was in full charge and the other fellow had gone.

The new man had the defective grates removed and a new set put in. The other fireman had piled coal into the furnace any way that was most convenient, but the new man put the coal in evenly and maintained a bed about 8 in. thick. By attending to his work he soon had the confidence of his chief engineer.

In another case I found a fireman operating with grate bars that had been heated excessively in the past and the weight of the coal had caused them to settle. The engineer and the fireman repeatedly asked the management for a new grate which was promised many times but never arrived. One day a new fireman came on the job, and as he was a good talker and had the backing of the engineer, he got the manager to order a new grate. It often happens that

managers will not take the advice of the old employees, but will take the word of a new man without question.

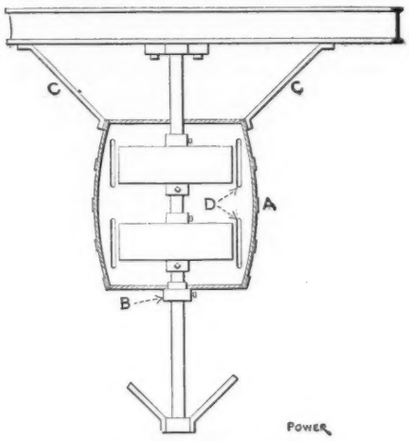
In another place the grate bars were in order, but the fireman had 14 in. of fuel heaped like a camel's back in the center. He soon lost his job. On the arrival of an expert the plant was shut down for 20 hours to put everything in order. Then a likely young fireman who had worked about the boiler room was given instructions in firing; the new man pulled through all right.

GEORGE RICE.

Melrose Highlands, Mass.

Novel Oil Baffler

A mule pulley in the finishing room of our plant threw an oil spray which damaged the stock and machines and made it unpleasant for the operatives.



BARREL OIL BAFFLER

To correct the evil I placed a flour barrel, *A*, around the pulley as shown in the illustration. The barrel was thoroughly reinforced throughout and a hole bored in the bottom to the size of the shaft. The braces were removed from the bottom of the shaft and the barrel slipped over the pulley into position. A collar *B* was fastened on the shaft to support the barrel, and braces *C* to the top of the barrel and I-beam for the same purpose. Slits *D* were cut in the barrel for the belt.

The device was a success as it has been in service for two months and prevents the oil from doing further damage.

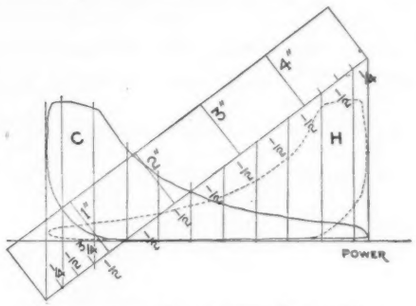
PETER VANDENBERG.

Paterson, N. J.

Doing without a Planimeter

For those engineers who do not use a planimeter, the following is a quick though an old way to divide a card into ordinates:

The cards should be about 4 in. long; if shorter, the end lines must be continued on a sheet of paper beneath the card. Along the atmospheric line place a square and draw a line perpendicular to the atmospheric line at each end of the card. Next place a rule diagonally across the card, as shown in the illustration, putting one end on one of the vertical lines and having the 5-in. mark touching the other.



POSITION OF SCALE FOR OBTAINING ORDINATES

Starting from either end, first mark off ¼ in. and then every ½ in.; this leaves a ¼-in. space at the other end. By placing the square on the atmospheric line again and drawing vertical lines through these points, the card will be divided into 10 equal parts. Adding the lengths of the ordinates and dividing by 10, and multiplying the quotient by the scale of the spring will give the mean effective pressure. The sum of the mean effective pressure of both cards divided by 2 gives the mean effective pressure to use in working out the horsepower of the engine.

JAMES A. CAMPBELL.

Providence, R. I.

Replacing a Tube Header

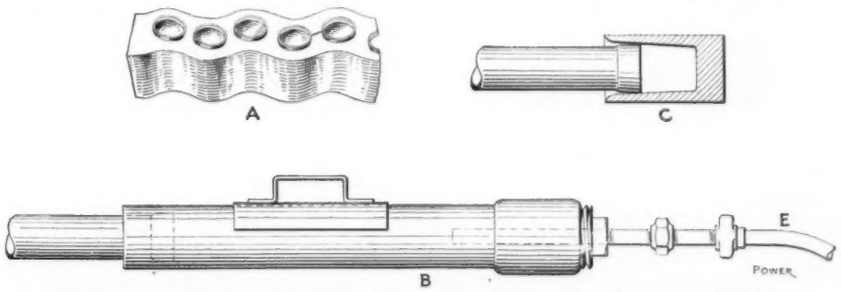
A tube header of the Babcock & Wilcox type cracked, as shown at *A*, in the illustration. As all the tubes were practically new it was decided to remove the header without disturbing the tubes in the header at the opposite end. Each was temporarily blocked to retain its original position and small holes were drilled in the header between the tubes. By driving drifts and chisels into these holes, the header was easily broken and removed.

The expanded ends of the tubes were then reduced by heating in a home-made forge, shown at *B*. This forge was made of old pipe and fittings, and a charcoal fire supplied with compressed air through the hose *E* gave good results. The forge was placed over the tube ends until they were heated to a cherry red, after which they were drawn by placing the tool *C* over their ends and hammering it. This tool tapers very slightly and by using a coarse taper in starting and a slight one in finishing, the work can be more quickly done.

Each tube was drawn to a ring gage of the original diameter of the tube, then the new header was placed over the tubes which were expanded in the usual manner. The opposite ends did not need rerolling. This process took less time than cutting out the tubes and replacing them and both headers.

A. M. QUINN.

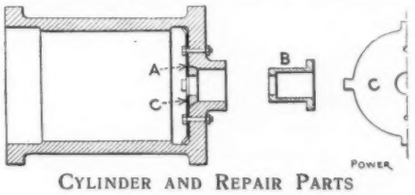
Canton, Ohio.



SECTION OF CRACKED HEADER, IMPROVISED FORGE AND REDUCING TOOL

Repair to an Engine Cylinder

While in charge of the machinery of a steamboat on the Great Lakes, where the continuous operation of the dynamo engine is important because the signal light must be bright, the dynamo engine blew out the shoulder in the stuffing-box as shown at *A*, permitting the piston-rod packing to pass up into the cylinder, causing a shutdown. The accident occurred on Lake Huron in a heavy sea at 2 a.m., the time incidents of that nature usually happen.



CYLINDER AND REPAIR PARTS

A piece of sheet iron ⅛ in. thick, cut as shown at *C*, was forced into the bottom of the cylinder so that the clips extended out into the counterbore. Two holes were then drilled through the bottom head where it was secured by two bolts as shown. The engine was repacked and in operation again in about an hour. It was kept in operation in that condition for four days, and except for slight leakage around the piston rod the operation was perfect.

On reaching an Ohio port a false or counter stuffing-box was made, as shown at *B*, and a smaller-size packing used. Two seasons after that the engine was still in good condition and using the false stuffing-box.

J. H. CUNNINGHAM.

Toledo, Ohio.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Results of Burning Screenings

Mr. Mowat states in his article under this title in the May 7 issue that coke screenings can now be burned with success where previously it was futile to attempt it. I have successfully burned screenings for the past six years in New York City and vicinity. Mr. Mowat does not tell the type of grates used, the percentage of air space or the type of steam-jet blowers. I think the first of these items is important in successfully burning coke screenings.

His statement that "the pressure in the ashpit corresponding to a given steam pressure at the blowers was determined by the rate of firing" leads one to believe that the ashpit pressure was not taken during the test, but was computed from the rate of combustion and the steam pressure on the blowers. If this is so, the inadequate method would lead to inaccurate test results.

It is also said that every two or three minutes the fire was stirred on top and leveled off. This may be good in testing for maximum efficiency, but is extremely poor boiler-room practice because the economy effected by burning the coke breeze would be counteracted by the heavy expense incurred by having extra firemen.

I agree with him, however, as to the benefits of balanced draft, but how was the steam consumption of the blower computed? Was it during the actual test or on a previous test? I ask this because the percentage of steam used by steam blowers is sometimes exceptionally low. On a Stirling boiler rated at 287 hp., with coke breeze almost identical with that Mr. Mowat used, I obtained a rate of combustion of 25 lb. per square foot of grate area, with an ashpit pressure of 0.76 in. of water and a net equivalent evaporation from and at 212 deg. per pound of moist coke, of 6.6 compared to his 5.4, which is his best figure. He obtained an efficiency of 52 per cent. whereas mine is 62 per cent.

With this boiler the percentage of builders' rating developed was 141 per cent., which is almost identical with Mr. Mowat's result. The water was measured by using calibrated scales and weighing the water and fuel accurately.

ERNEST D. FIEUX.

New York City.

Erecting a Large Engine Flywheel

F. C. Holly's article under this heading in the Dec. 12 issue should prove of great value to most engineers. POWER should have more such articles. Articles on placing and aligning cylinders and bedplates of both horizontal and vertical engines would be welcome.

What size rope blocks would Mr. Holly use in turning half of a flywheel around the shaft, as mentioned in his article, the weight being about 5½ tons?

O. G. A. PETTERSON.

Manitoba, Canada.

Engineers All Dead

The foreword under this heading in the May 7 issue deserves the highest commendation. It makes an engineer feel proud after reading it. To know that the engineers of the "Carpathia" so willingly responded to their captain's call for "full speed ahead" when rushing to aid the "Titanic" is also gratifying.

J. H. POWELL.

Brooklyn, N. Y.

The Rateau Regenerator

An article in POWER, Apr. 23, reviewed the subject of steam regenerators. While it gives an interesting description of one of the types of my apparatus, it classifies the latter among the variations of this type which have been proposed since my invention. I feel obliged, therefore, to recall to you that my patents deal in general with the recuperation of exhaust steam by means of a receptacle inclosing masses capable of absorbing heat and interposed between the exhaust of engines running intermittently at high pressure and the admission of a machine running continuously at low pressure.

Let me add that my patents protect not only a definite type of apparatus, such as is represented by Fig. 1 of the article in question, but any accumulator of steam in which the water, whether by itself or conjointly with a metal, serves as the agent of accumulating the heat. What is more, I possess a patent, issued in 1901 which deals with an apparatus comprising superposed plates or equivalent bodies retaining the heat, between which the water falls from one plate or receptacle to the other.

The applications which I have made of the process invented by myself are extremely various and I therefore feel that the article you have published appears to unwarrantedly restrict the range of my invention.

A. RATEAU.

Paris, France.

Mr. Dickson's Pump Troubles

Mr. Dickson's letter in the Apr. 23 issue reminded me of a similar experience with a pulsometer pump. It defied the efforts of several to make it pump water and eventually I was asked to find the trouble. The piping was arranged as shown in Mr. Dickson's sketch. Examination showed the pulsometer to be all right, so the suction pipe was raised 6 in. As no further trouble occurred it is supposed that the end of the pipe was submerged in mud until lifted. This must have caused Mr. Dickson's trouble.

JAMES W. WILDE.

Pawtucket, R. I.

Where the Coil Should Be Placed

The illustration shows a simple and effective water-heating arrangement that may answer the requirements of Angelo Belmonte as stated in the Apr. 30 issue.

Provide a 30-gal. tank *A*, such as is used in connection with kitchen ranges, and support it at an elevation higher than the boiler. If the boiler is in a basement the tank may be hung from the beams of the floor above. Connect the city water or tank-supply pipe *B* almost to the bottom of the tank, as shown. Near this connect the pipe *C* to the bottom of the tank, running it down one side of the boiler setting.

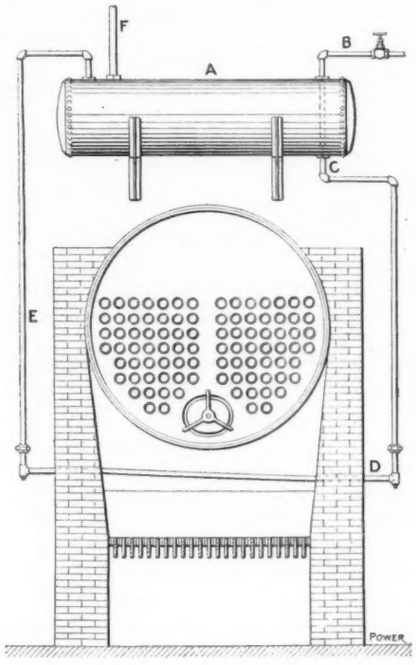
At a point where it will be exposed to the hot gases as at *D* introduce another pipe into the setting. This should run across the boiler and emerge at a point about an inch higher than where it enters. Tees connected to each end of this pipe and plugged afford a convenient means of cleaning out the mud and scale that accumulates.

The size of this pipe depends entirely upon the amount of water to be heated. If it is for a moderate-sized flat building, say four apartments, a 2-in. pipe will probably be satisfactory.

Where the pipe emerges from the boiler setting run another pipe *E* to the tank, connecting it so that the hot water

will enter at the top of the tank. Near this, also at the top, connect the service pipe *F*. A union on each side of the boiler where the pipes from the tank connect with the heating pipe provides an easy means of renewing the heater pipe should it become plugged with scale.

Avoid drops in the circulating pipe, as otherwise a pocket of steam will form,



PIPING OF HOT WATER TANK

causing water-hammer; that is, there should be a continuous upward slope from the point where the pipe enters the boiler to where it enters the tank.

If it is more convenient, the heater pipe may have a return bend, emerging alongside of the point where it enters. In this case also the outlet should be higher than the inlet. This method is not as desirable as the heater pipe is harder to keep clean.

Ordinary steel or wrought-iron pipe should be used for the heating pipe as it transmits the heat more readily than the heavier weights. There is no danger of explosion; should steam form it will merely force the water back in the city main.

J. F. MOWAT.

Joliet, Ill.

Mr. Belmonte's arrangement would be similar to an economizer for heating the feed water for boilers except that, in his case, the water would not need to be raised to so high a temperature. By locating a number of tubes connected at each end to headers or manifolds, in the flue leading from the boiler to the stack, the heat in the waste gases can be used. Mr. Belmonte does not give the temperature of these gases nor the amount of water to be heated, but, by proportioning the number of square feet of heating surface of the tubes to the temperature of the gases and the quantity of water to be heated he can readily get the results desired.

The best location for the arrangement must be determined by the space available as well as by the temperature of the gases. If the gases are extremely hot, the tubes should be placed near the stack; where the gases are cooler, there would be no advantage in subjecting them to very high temperatures.

The best material for both the tubes and the headers is undoubtedly cast iron. This is conclusively borne out in economizer construction. Gases of comparatively low temperatures have a much more deleterious effect on such tubes than those in the boiler itself, particularly if there is much sulphur in the coal.

Where cold water is used in an economizer or device of this kind, the tubes have a tendency to sweat, which also helps to form sulphuric acid. To prevent this, it is advisable to mix some of the hot water discharged with the cold entering water. This can be done by means of simple piping and is quite common in connection with economizers where feed-water heaters are not used.

The piping should be so arranged that the water will flow in the opposite direction to that of the gases. In this way the coldest gases will impinge on the tubes where the water is the coldest.

A relief valve should be attached to eliminate danger from explosion. There is always a danger that one of the tubes will clog, thus stopping the circulation and permitting the stationary water to get hot enough to burst the pipe.

In making an installation of this kind, however, the first thing to ascertain is that there is sufficient draft to take care of the gases with this added impediment to their flow.

EVERARD BROWN.

Pittsburgh, Penn.

A pipe or coil should not be placed in any part of the combustion chamber of a return-tubular boiler for the purpose stated by Mr. Belmonte. Placing a pipe there makes absolutely necessary a constant circulation through the pipe and a constant stream of cold water leading to the coil: if it is connected, for instance, to a kitchen-range boiler, the water will probably get hot throughout, and, due to the intense heat in the combustion chamber, will heat the water quicker than it can travel through the pipe. The water in the coil or pipe will then separate, a steam pocket will be formed, the pipe overheat, and when the water rushes back it is almost certain to cause a break. Even if this did not happen, a burned-out pipe would probably result in a short time.

JOHN THORN.

London Junction, Ont.

Troublesome Condenser

The condenser layout described by Mr. Jacobs in the Mar. 12 issue is poor throughout and will not work without a few changes being made. As he obtains only a 22-in. vacuum and it is a 24-ft. drop to the lake, he cannot raise the water. As mercury is 13.6 times the weight of water,

$$\frac{22 \times 13.6}{12} = 24.93 \text{ ft.}$$

leaving only 0.93 ft. head to overcome the resistance of the four 4-in. ells and the 325 ft. of 4-in. pipe.

The best way to correct the evil is to put a motor-driven centrifugal pump on the suction line running to the lake. This will boost the water up to the condenser. If the discharge from the air pump has a drop of a few feet directly from the pump to the lake, no harm will be done if the vacuum breaks.

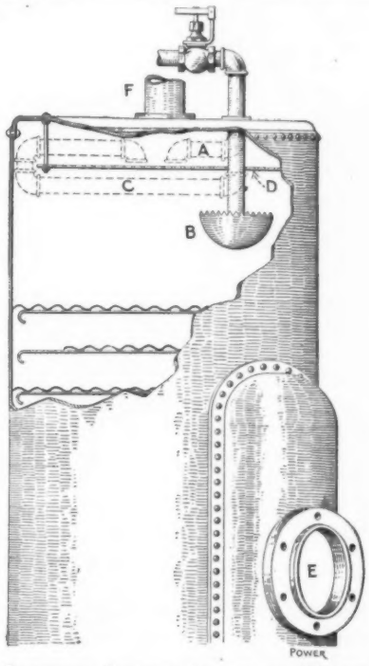
C. V. BENNETT.

Chicago, Ill.

Noisy Heater

As is suggested in recent letters answering my inquiry under this heading in the Feb. 6 issue, I submit illustrations to give a clearer idea of the heater.

Mr. Hoppe's suggestion in the Mar. 26 issue is not feasible, as a study of the sketch will confirm. Mr. Meinzers' suggestion, in the same issue, was carried out by heating the water before it entered the steam space and by partially sealing the cold-water supply pipe, but the heater made more noise than before.



SHOWING SUPPLY PIPING TO WATER HEATER

The dotted lines *A* show the first change made in the cold-water supply pipe, thus eliminating the overflow box *B*. The dotted lines *C* show a further change made in

this pipe in an attempt to temper the water before it mingled with the exhaust steam. I put in the round plate *D* through which the water percolates in fine streams, enabling it to be heated more quickly. The exhaust-steam inlet is shown at *E* and the outlet at *F*. I admitted hot water to the cold-water supply before it entered the heater. This reduced the noise on light loads, but on the heavy night loads, when more water was evaporated, the noise increased.

I now feel sure that the steam in the heater condenses, creating a vacuum which breaks and causes the noise; it is not due to water-hammer. However, while I am experimenting, will others interested offer suggestions?

L. C. GREENE.

Gallipolis, Ohio.

Mr. Jacobs' Condenser

B. A. Jacobs' condenser, mentioned in the Apr. 30 issue, will never work satisfactorily until the lift is shortened on the water-suction line. The pump is working against a static head of 24 ft. plus the friction of four ells and 300 ft. of pipe. Manufacturers do not guarantee jet condensers and air pumps to work satisfactorily with more than 20-ft. lift and 5-ft. discharge head.

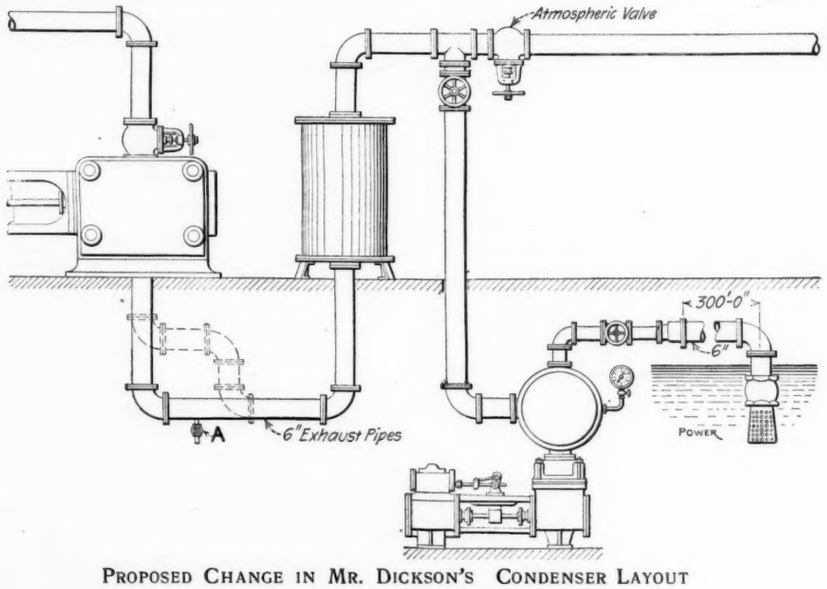
If the condenser was arranged as illustrated, the lift would be shortened at least 6 ft. and the friction of two ells saved; all the pipe line must be absolutely tight.

I suggest changing the exhaust line as shown, thus saving two ells; also put in a 1-in. drain, *A*, to avoid water-hammer when the engine is started after several hours' shutdown. If the condenser loses its vacuum while the engine is running, there being no automatic atmospheric valve, the results will depend upon the load on the engine. If it is doing its rated horsepower or is slightly overloaded when the vacuum is lost the engine will slow down and probably stop before enough back pressure is accumulated to wreck the condenser.

If the engine is working light and the vacuum is lost, the governor will lengthen the cutoff and admit more steam to the condenser until the back pressure ruptures it or stops the engine.

C. E. ALDRICH.

Tranquility, Calif.



PROPOSED CHANGE IN MR. DICKSON'S CONDENSER LAYOUT

Balanced Draft Systems

The balanced-draft systems described in POWER recently were of much interest to me and perhaps others may be interested in the arrangement in our plant.

We operate water-tube boilers of 350 hp. each, which furnish steam to three 1000-kw. units. The forced draft is obtained from a fan and is automatically regulated; natural draft is regulated with individual dampers for each boiler by a rod extending from the front to the rear, where the damper-chain is wound around it to suit the position of the damper, thus making it possible for the firemen to adjust the dampers to any desired position.

For 16 of the 24 hours of daily operation the load is nearly uniform and the fan runs at uniform speed which enables the firemen to obtain a balanced draft.

During these hours the gas samples taken average from 9 to 14 per cent. of CO_2. The other eight hours the load is variable; therefore we cannot obtain balanced draft at all times, which lowers the percentage of CO_2 considerably.

Another advantage of balanced draft is that it keeps the fires more level. I have found that with an excess of draft above the grates the air will flow through the fuel bed very rapidly, and will not come in contact with the fuel, but when it goes through, the oxygen in excess of that which unites with the carbon and hydrogen escapes up the chimney. With balanced draft the air does not go through so rapidly and more oxygen will unite with the carbon after it has entered above the fuel bed. We also fire alternately and only one furnace door is opened at a time, which greatly aids in reducing the CO.

A. NORRMAN.

Pottsville, Penn.

The Arithmetical Mean

Mr. Richardson makes a good point in the May 7 issue relative to my article on the arithmetical mean when he calls attention to the fact that the first and last of a series of observations upon a variable quantity should be averaged with only half the weight of the others. When the measuring apparatus is so elaborate as to be recording, however, it is likely that an averaging instrument will be applicable and available. When such is the case, the rule given is not needed for the mean height of either rectangular or polar charts.

Mr. Richardson implies that the question, in the case of the venturi meter, whether to take the average of the square roots of the readings or the square root of their average is purely an academic one. There is a large class of engineering measurements, depending upon the relation that the desired quantity equals a constant multiplied by the square root of a measured head. The instrument is not always graduated in terms of the desired quantity, but in inches or feet of head, as, for instance, hook gages for weir measurements, pitot tubes for air or gas lines, manometers used on standard orifices, etc. When this is the case, a calibrating curve is used by which the desired quantity can be obtained at once from the instrument reading without calculation. It is to such cases that my illustration of the venturi meter applies.

JULIAN C. SMALLWOOD.

Syracuse, N. Y.

Testing Engines with a Prony Brake

My experience with water-cooled prony brakes is similar to that of Allen Slade, as told in the Apr. 16 issue. To overcome my trouble I put two pieces of ordinary white soap between the brake bands so that they would rub on the wheel; then the supply of water was cut down until a little steam was formed, and the brake worked perfectly. This method was used on a pulley 12 in. in diameter with a 12-in. face and took care of 10 hp. at 750 r.p.m.

Oil is all right up to the point where excessive heating occurs, but water and soap will work more satisfactorily under such conditions.

A. T. KASLEY.

Swissvale, Penn.

Inquiries of General Interest

All Questions Must be Accompanied by Name and Address—Not for Publication

Diaphragm Pump

What is a diaphragm pump, and how does it operate?

J. J. F.

A diaphragm pump is one in which the displacing action is obtained by reciprocating a circular or other shaped diaphragm of rubber, leather or other flexible material, fastened and sealed at its edges to the pump body. The space underneath the diaphragm forms the suction chamber. When designed for raising liquids, this pump is usually so arranged that the diaphragm will be horizontal, with a delivery check valve in the center of the diaphragm. In operation, the diaphragm is reciprocated by short strokes in and out of the suction chamber by a pump rod attached to the central portion of the diaphragm. The principle of the pump is similar to that of a bellows.

Indicating a Pump

How is a pump indicated which has no outside parts suitable for the attachment of a reducing motion?

S. C.

The indicator cock connections to the cylinders are made in the same manner as in indicating an engine. Attachment for the indicator motion is obtained by extending the piston rod, like a tail-rod, through a stuffing-box set in the head of the steam or water cylinder. Such a tail-rod need not be over about one-quarter the diameter of the main piston rod and is readily attached by drilling and tapping a hole in the end of the piston rod for receiving the screwed end of the tail-rod.

Sweating of Iron Water Tank

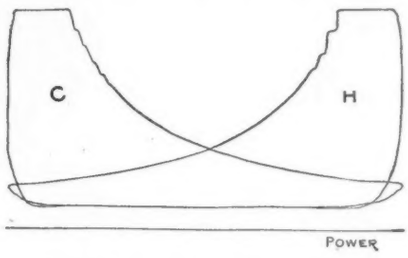
What preparation can be applied to a steel water tank to prevent sweating?

J. O. W.

So called "sweating" is not water which oozes through from the inside of the tank, but is moisture deposited by condensation from the air due to reducing its temperature by contact with the tank to a point where it contains more moisture than it can hold in suspension. The remedy is to cover the sides and bottom of the tank with a nonconducting covering which will present a surface to the air that is nearly the latter's temperature. The covering should be applied when the tank has been empty long enough to have attained the same temperature as the air; otherwise some moisture will be inclosed and soon saturate the covering, nullifying its noncondensing properties. For the same reason the covering should be protected from rain.

Sticking of Indicator Piston

These diagrams were taken with a new indicator from a 22x22-in. ice-plant Corliss engine making 56 r.p.m. What causes



STICKING OF INDICATOR PISTON

the notches in the expansion lines of the diagrams?

V. K. S.

The very sharp cutoff and the square corners of the notches in the expansion lines are undoubtedly due to the sticking of the indicator piston in its cylinder. This imperfect action is likely to occur from lack of lubrication, or from neglecting to thoroughly blow out all pipe scale and loose dirt from pipe connections before applying an indicator.

Unequal Pipe Expansion

In a steam-heating system, will the expansion of two parallel straight lines of iron or steel piping, run as a main and its drip main, each 150 ft. long, be the same for corresponding points along their length; that is, will the difference of expansion be so little, that the two pipes may be connected together at intervals by tees and close nipples? What would be the cause of difference of expansion? What should be the controlling considerations in proportioning the largest size of low-pressure steam-heating main that can be supplied through a pressure-reducing and regulating valve connected to a stated size of high-pressure supply pipe?

G. W. R.

For a variety of reasons the two pipes will not expand alike, nor will they contract to their original fitted-up lengths after being once heated. The evidence of unequal expansion and contraction of pipes is to be observed in the distortion which takes place in the pipes of a wall coil made up only of straight runs of pipe connected together by headers, without any mitre or spring ends. The connecting together of two such pipes results in warping and buckling the first time steam is turned on, and if connected together by close fittings would probably result in rupture of the latter.

The leading causes for difference in expansion are actual difference in texture of the material of the two pipes and actual difference of temperature.

Difference in texture of material may result from variations in raw material, method of manufacture and chance differences in mechanical treatment which a pipe may receive from the time it is first formed down to the last finishing touches of the steam fitter, and it is practically impossible to warm up two such pipes to absolutely the same temperature or to expose them to absolutely the same cooling effect from the surrounding atmosphere.

Reducing regulating valves are supposed to be ample for delivering all steam that can flow through high-pressure pipes, corresponding to the sizes of their inlets within the ranges of pressures for which they are supposed to be used. To deliver any given amount of steam from ordinary high pressures, reduced to the ordinary low pressures used in steam heating, it is a good rule to have the low-pressure pipe eight times the diameter of the high-pressure connection.

This ratio assumes that the pressure regulator is capable of delivering the full capacity of the pipe size of the high-pressure connection.

Lap of Belts

What is the proper length of lap for single and double belts, 4 to 18 in. wide?

P. E. M.

Most manufacturers make the scarf length equal the belt width for all single and double belts, down to 5 in. wide; and for belts of less than that width make the scarf about 1 in. longer than the belt width. Double belts over 10 in. wide should have the scarf ends each covered with a tuck or dovetail, formed by a narrow overlap of the corresponding thickness of the opposite end of the belt

Study Questions

This Week's Questions
Last Week's Answers

26. A locomotive is stopped with the piston on one side at the head end of its stroke. It is found that the distance from the center of the crosshead to the center of the driven axle on this side is 7½ ft., while on the other side it is 6 ft. 1½ in. What are the crank and connecting-rod lengths, center to center?

27. Given the same conditions as in question No. 22 (answer to which is printed below) except that the tank is to be open, i.e., without a top, what then should be its dimensions?

28. Convert 5, 14, 41, 68, 158 and 266 deg. Fahrenheit to Centigrade; and 1, —30, —25, 90 and 120 deg. Centigrade to Fahrenheit.

29. If a cubic foot of wrought iron weighs 480 lb., what is the weight of a flat bar 2 in. wide, ½ in. thick and 1 yd. long?

30. What horsepower will be required to pump 108,000 gal. of water per hour from a coal mine 250 ft. deep, neglecting friction in the pipes, etc.?

Answers to the above will appear in the next issue. Answers to last week's questions follow:

21. It would take 2 hr. to go up a hill 30 miles long and 1 hr. to return, or 3 hr. in all for the 60 miles. On the level the same distance is covered in the same time, 60 miles in 3 hr. Therefore, whatever the contour of the course, the round trip will be made in the same time as though the course were entirely flat. It will therefore take 5 hr. to go 50 miles and return.

22. Taking the weight of a cubic foot of water as 62.5 lb., the volume of 500 lb. is 8 cu.ft. A sphere has the least surface for a given volume (shown by soap bubbles and toy balloons); and among rectangular objects, a cube is the nearest like a sphere; therefore the tank should be cubical. A cube containing 8 cu.ft. will measure on each edge

$$\sqrt[3]{8} = 2 \text{ ft.}$$

The inside of the tank then will measure 2 × 2 × 2 ft. and its surface 6 (2 × 2) = 24 sq.ft.

23. As the strength and weight will both increase with increase of area of cross-section and in the same proportion, the size of the wire is not necessary to the calculation. For convenience take the cross-sectional area as 1 sq.in.; then the tensile strength is 40,000 lb. and the weight of a length of 1728 in. is 555 lb. The length of the wire in feet that will break with its own weight is

$$40{,}000 \div \frac{555}{1728} \times 12 = 10{,}378.38 \text{ ft.}$$

24. Between freezing and boiling on the Fahrenheit scale is

$$212 - 32 = 180 \text{ deg.}$$

and on the Centigrade scale

$$100 - 0 = 100 \text{ deg.}$$

A Fahrenheit degree therefore is $^5/_9$ of a Centigrade degree and a rise of 45 deg. on a Fahrenheit thermometer corresponds to a rise of

$$45 \times {}^5/_9 = 25 \text{ deg.}$$

on a Centigrade thermometer.

25. A displacement of 1.25 gal. per revolution equals

$$1.25 \times 8.3356 = 10.4195 \text{ lb. per revolution}$$

Corrected for slip,

$$10.4195 \times 0.80 = 8.3356 \text{ lb.}$$

A boiler horsepower of 30 lb. an hour is 0.5 lb. a minute

$$\frac{8.3356}{0.5} = 16.6712 = \text{boiler horsepower per revolution per minute}$$

DuBois N. A. S. E. Convention

On June 7 and 8 the Pennsylvania State Association, N. A. S. E., held its thirteenth annual convention at DuBois, Penn. It was well attended by both delegates and members of the American Supply Men's Association.

The convention opened on Friday morning with the usual formalities at Eagles' Hall. Addresses of welcome were made by A. L. Cole and F. S. Weber, for the city of DuBois, National President E. H. Kearney and State Deputy John M. Lynch responding. During the business session, State President Bumiller delivered an address on education and legislative uplift.

In the afternoon the members, escorted by Superintendent of Motive Power Harrison, visited the B., R. & P. locomotive shops.

Later the party was taken to the DuBois Brewing Co.'s big plant, where a luncheon was served to its visitors.

At the Saturday morning session the following officers were elected and installed by President Kearney: State president, N. D. Orms, of Johnstown; vice-president, A. C. Cotton, Pittsburgh; secretary, Albert Munsinger, Williamsport; treasurer, D E. Seeley, DuBois; conductor, W. C. Smyor, Sharon; doorkeeper, J. D. Rostum, Chester.

Sixty delegates and supplymen attended the banquet at the Forte Worth Hotel in the evening, at which Samuel B. Force acted as toastmaster. Among the speakers were National President Kearney, President Bumiller, State Treasurer Seeley, and Messrs. Green, Johnston, Walbieser, Lynch, Cole and Weber.

The Exhibits

The supplymen's exhibits were attractively displayed at Eagles' Hall and were inspected by a large number. The following firms exhibited: Clement Restein Co., Philadelphia; the Fairbanks Co., Pittsburgh; the Atlantic Refining Co., DuBois; Alberger Pump Co., Alberger Condenser Co., Pittsburgh; Jenkins Bros., Philadelphia; H. W. Johns-Manville Co., New York; V. D. Anderson Co., Cleveland; Quaker City Rubber Co., Philadelphia; Home Rubber Co., Trenton, N. J.; Dearborn Drug & Chemical Works, Pittsburgh; the Lagonda Manufacturing Co., Pittsburgh; POWER, New York; Bird-Archer Co., New York; Garlock Packing Co., Palmyra, N. Y.; the Lunkenheimer Co., Cincinnati; Greene, Tweed & Co., New York; International Correspondence Schools, Scranton, Penn.; the Vulcan Soot Cleaner Co., DuBois; *National Engineer*, Chicago; Osborne Machine Co., DuBois; Anchor Packing Co., Pittsburgh; Crandall Packing Co., Palmyra, N. Y.; Eagle Lubricator Co., Pittsburgh; Epping-Carpenter Co., Pittsburgh; Homestead Valve Co., Homestead; Ridgway Dynamo & Engine Co., Ridgway; the Peerless Rubber Co., New York; the Westinghouse Manufacturing Co., Pittsburgh; the Liberty Manufacturing Co., Pittsburgh.

Indiana State N. A. S. E. Convention

The eighth annual, and probably the most successful, convention of the Indiana state organization of the National Association of Stationary Engineers passed into history Saturday evening, June 8, after three days' session at Evansville.

The meeting opened at 10 a.m., June 6. Emil Heeger, chairman of the state association, after a brief address, introduced City Attorney George A. Cunningham, who represented Mayor Charles Heilman. Mr. Cunningham emphasized the important work of the engineer and the debt which humanity owes him, lauding the purpose of the association and expressing the hope that it would attain the success it so richly deserves.

National Vice-president John McGrath in his response briefly outlined the purposes and principles of the association, thorough education, sane license laws and civil-service examinations or their equivalent in the selection of engineers for the public employment.

F. E. Ramsley, president of the Central State Exhibitors Association, explained the object of conducting an exhibit at a convention. The displays are made to familiarize engineers with the various materials and devices on the market; and immediate returns are not expected. An adjournment was then taken until 1:30 p.m., when a short closed meeting was held at which the officers' reports were

read and acted upon. A discussion upon ways and means of propagating the association brought out many valuable suggestions.

At the evening session, National Secretary Fred Raven spoke of the splendid work and coöperation of the supplymen in making the convention a success. He urged all interested in the association to do their best missionary work and bring in as many new members as possible that the organization might continue to prosper and be an institution of benefit to all.

R. V. Stuerve, of the Allis-Chalmers Co., gave a lecture on "Steam Turbines," illustrated with many stereopticon slides showing the principles of design, the construction of the various parts and numerous typical installations. He first briefly enumerated the several characteristics of the two pure types of turbine, impulse and reaction, and then took up their construction step by step and pointed out the interesting features of operation.

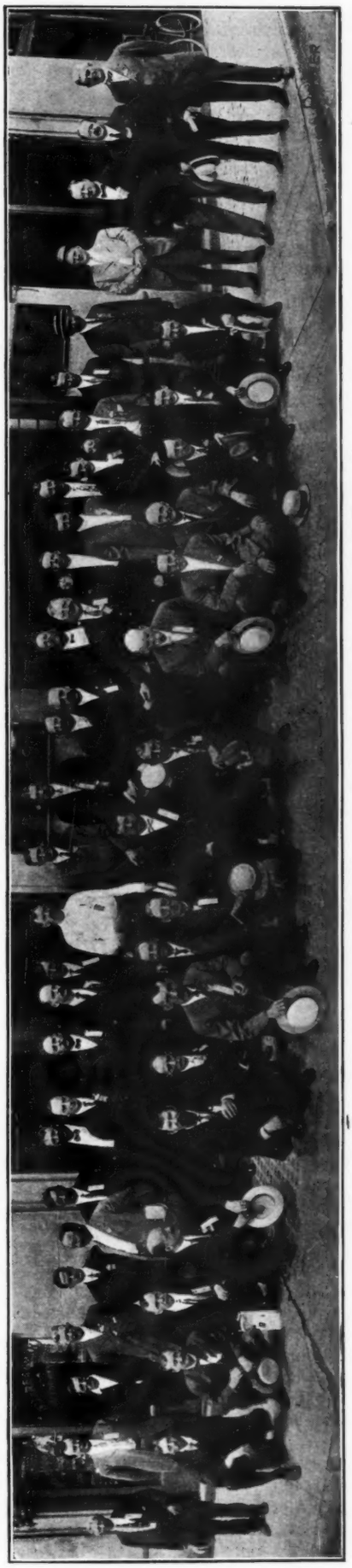
At the Friday morning session, Vice-president John McGrath gave a long welfare talk. Fred Raven, speaking on organization, gave as one sure way to make any organization robust and healthy to elect competent officials. He reminded his hearers that the state and subordinate associations may obtain advice and personal and financial aid from the national body if they will plainly state their wants.

In the afternoon the delegates and guests visited the Evansville Manual Training School and the plants of the Cook Brewing Co. and the Evansville Brewing Association. Later many visited the Fair Grounds where an aviation circus was in progress.

At the evening meeting, Theodore Wineshank, a heating engineer and contractor of Indianapolis, gave a lecture on "Vacuum Heating," illustrated with slides. Having shown that the latent heat of steam produces the main part of the heating effect, and hence low-pressure steam is practically as effective as high-pressure, he described the essential features of various types of installation. The various devices employed were also explained, such as thermostatic valves, "modulation" valves, which in one turn of the handle swing from the closed position to the wide-open; vacuum-controlling valves, etc. He also displayed views of various types of radiators, ventilating fans and air washers.

A smoker and buffet luncheon, given by the entertainment committee, followed. The program was largely impromptu, Toastmaster Raven unexpectedly calling on each to contribute his share.

At the closed session Saturday morning, Terre Haute was chosen as the next meeting place and the following officers were elected: Charles Streithof, Evansville, president; George R. Fields, Terre Haute, vice-president; Louis Minke, Evansville, secretary; Albert Franke, Terre Haute, treasurer, and Emil Heeger, Evansville, state deputy.



SOME OF THOSE WHO ATTENDED THE MEETING OF THE INDIANA STATE N. A. S. E. AT EVANSVILLE

In the afternoon an automobile ride was taken through the city and dinner was served at Cook's Park. Following the dinner, Secretary Raven installed the new officers and presented the past president's jewel to H. E. Smith.

The exhibit hall was well arranged and the following members and associates of the Central States Exhibitors Association had effective exhibits: American Steam Gauge & Valve Manufacturing Co., V. D. Anderson Co., Crandall Packing Co., Dearborn Drug & Chemical Works, Garlock Packing Co., Greene, Tweed & Co., Hawk-Eye Compound Co., Hills, McCanna Co., Home Rubber Co., Jenkins Bros., H. W. Johns-Manville Co., Keystone Lubricating Co., Lunkenheimer Co., Osborne Valve & Joint Co., William Powell Co., POWER, Schaefer & Budenberg Co., C. E. Squires Co., United States Graphite Co., Cling-Surface Co., Diamond Power Specialty Co., Kollker Electric Co., H. Mueller Manufacturing Co., *National Engineer*, A. L. Swanson & Co.

A. O. S. E. Convention

The twenty-sixth annual convention of the Supreme Council of the American Order of Steam Engineers was held at Allentown, Penn., during the week commencing June 3. The Allen House was the headquarters. Twenty-three councils of the order were represented by 105 delegates, and there were also present many past presidents and prominent members of the organization.

The Supply Men's Association, connected with the order, held its mechanical exhibition in the main hall under the grandstand at the fair grounds of the Lehigh Agricultural Society. The display was tastefully arranged and interesting to the delegates and visitors. The several business sessions of the convention were held in an adjoining hall.

The exhibit was formally opened on Monday evening with a short address by Past President Richard Foley. He then introduced Attorney Fred B. Gernerd, who spoke interestingly of Allentown.

On Monday morning, Mayor Charles W. Rinn welcomed the convention to the city. Supreme President Louis G. Schlehner's report shows progress in every department, and the secretary's report shows the association to be in a prosperous financial condition.

It is expected that the coming year will be a healthy one in the increase of members. Heretofore operating engineers only were admitted, but now that the supreme body has let down the bars other than operating and licensed engineers are eligible to membership.

The entertainment features included automobile rides for the ladies, a trip by

trolley to Central Park, an enjoyable vaudeville entertainment in the exhibit hall, and a concert by the Bethlehem Steel Co. Band, also in the exhibit hall.

The delegates elected the following supreme officers: D. B. Heilman, chief engineer; George W. Goodwin, first assistant engineer; E. Harding, recording engineer; F. J. Armbuster, corresponding engineer; Michael Helmstridt, treasurer; Thomas Montgomery, senior master mechanic; Thomas Marshall, Jr., master mechanic; W. H. Baer, chaplain; W. J. Courtney, inside sentinel; Philip Kirkwood, outside sentinel; Louis G. Schlehner, William Parient and W. S. Smith, trustees.

At the final meeting of the Supply Men's Association the officers elected for the ensuing year were: Frank Martin, president; Frederick L. Jahn, vice-president; Charles Wilhoft, secretary; John W. Armour, treasurer; Hart Hill, director of exhibits. Handsome tokens of appreciation were presented to the retiring president and director of exhibits, and also to the treasurer.

The following firms occupied booths at the convention: John R. Livezey; Lyons, Borgner Co.; Bird-Archer Co.; Frill Indicator Co.; Greene, Tweed & Co.; Keystone Lubricating Co.; Rooksby & Co.; New York Belting Co., Ltd.; Engineering Supply Co.; George W. Lord Co.; William C. Robinson Son & Co.; H. B. Underwood Co.; Philadelphia Bourse Co.; Hawk-Eye Compound Co.; Crandall Packing Co.; the Roto Co.; R. & J. Dick, Ltd.; France Packing Co.; Lagonda Manufacturing Co.; *Popular Engineer;* Anchor Packing Co.; Strong, Carlisle & Hammond Co.; Liberty Manufacturing Co.; *Practical Engineer;* Warren Webster Co.; Home Rubber Co.; Jenkins Bros.; Dearborn Drug & Chemical Works; POWER; Albright Son & Co.; New York & New Jersey Lubricating Co.; the Fairbanks Co.; Westinghouse Air Brake Co.; National Tube Co.; McLeod & Henry Co.; Diamond Power Specialty Co.; McArdle & Cooney; Watson & McDaniel Co.; Lewis-Rott Co.; the Lunkenheimer Co.; Garlock Packing Co.; *Southern Engineer;* Macon, Jr. Co.; Buhne Metal Co.; Ashton Valve Co.

It was decided to hold the 1913 convention at Philadelphia, Penn.

Baltimore Engineers Club

The Engineers' Club, of Baltimore, held an important meeting Thursday evening, June 6, the last before the fall. The officers elected for the ensuing year are R. Keith Compton, president; George W. Wright, vice-president; W. W. Pagon, secretary, and J. Fletcher Apsey, treasurer. The new directors are W. W. Crosby, Emory Sudler and B. C. Howard. Holdover directors until 1913, Oscar F. Lackey, John K. Flick and Swepson Earle.

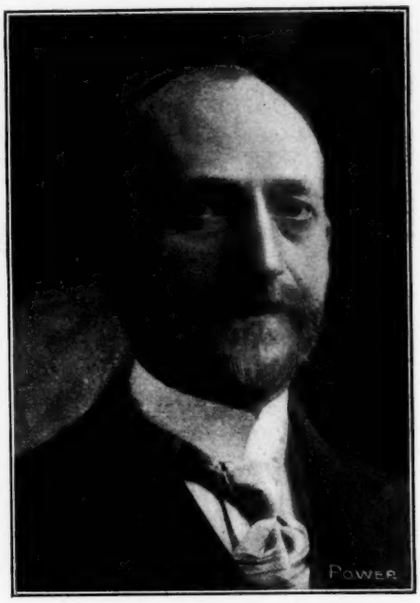
The matter of changing the club name to the Engineers' Society of Baltimore, or the Engineers' Society of Maryland, will be decided definitely at the first fall meeting.

In the discussion relative to securing the 1913 convention of the American Society of Civil Engineers for Baltimore, Mr. Earle asked the members to exert all possible efforts to get it and William D. Janney was designated to go to New York and have a conference with Charles Warren Hunt, secretary of the American Society, to that end.

OBITUARY

THEODORE ALBERT

On May 27, Theodore Albert, president of the William Powell Co., Cincinnati, Ohio, died at his home in that city.



THEODORE ALBERT

Mr. Albert's career is a notable example of the boy who from a humble beginning makes the best of his opportunities and by perseverance and hard work wins his way to the top. Nearly 40 years ago, at the age of 18, he commenced his business life in the employ of the Powell company as an office boy. The company at that time was modest in size and capacity. Step by step, Mr. Albert was given added responsibility, first as bookkeeper, then assistant manager, manager, and finally upon the death of James Powell, in February, 1908, he succeeded him as president.

Among his fellow officers, some of whom knew him intimately for over 20 years, he was known as a man of modesty, indefatigable energy and industry and his friends held him in the highest honor and trust.

Mr. Albert never married but devoted his home life to his mother, whom he survived by only about a year. Between them existed a very deep affection and their life together was a beautiful example of mother and son comradeship.

Milwaukee Smoke Inspector's Report

By a state smoke-abatement law recently passed, the Wisconsin legislature gives a city smoke inspector jurisdiction over all territory one mile from the city limits. This law, says Charles Poethke, smoke inspector of Milwaukee, in his yearly report now does justice to manufacturers just within the city limits where formerly a far worse offender outside the line could not be reached.

While the law was strongly opposed by the railroads, the protests of a large committee of citizens convinced the legislature of its necessity. One of the offending railroads has already equipped its power plant with automatic smokeless furnaces.

Two deputy inspectors have been appointed to Milwaukee's department and greatly increase its efficiency. Where it formerly required two men to prove a violation of the ordinance, one as a complainant and the other as a witness, a deputy can now get a conviction with the assistance of a camera. Every violation is photographed by the inspectors and the time the photograph was taken is marked on the smoke chart together with the length of time the violation continued. The court has in all cases sustained the work of the department, imposing fines on all offenders where the evidence warranted a prosecution.

Many firms, states Mr. Poethke, seem to think that the installation of a certain smokeless furnace or stoker is all that is necessary and are surprised when a violation is charged against their plant. This is due to men operating these furnaces contrary to instructions or being incompetent, or negligent in their duties. No fireman should be permitted to run any mechanical stoker without being fully acquainted with its operation. Many good stokers and smokeless furnaces have been condemned just for this reason. Every stoker manufacturer will guarantee his device to do the work and no payment to be made until satisfactory and approved by the smoke department. Smaller plants as a rule resort to Pocahontas coal where the boiler setting or other circumstances will not permit installing mechanical or other furnaces. Hard-coal dust is also used to some extent, but as the market is limited and it cannot be had at all times it is not in great favor, especially when draft conditions are poor.

An ordinance, at present pending before the Milwaukee Common Council, prohibits using soft coal on railroads, tugs and steamboats within the limits of the city and one mile therefrom.

Moments with the Ad. Editor

Is There Anything Not Advertised In POWER That Ought To Be?

We have called the Selling Section the engineer's ready catalog and reference, to which he can go for the things he wants, just as the man goes to the card catalog of a great library to find what the library contains on the subject in which he is interested.

Now when a man goes to a library, he glances over the names of the books listed, chooses the ones whose titles and contents seem most attractive, and sends to the book-stacks for these.

But, he runs on snags—sometimes.

No library in all the world is altogether complete, with the possible exception of the Bibliotheque Nationale at Paris.

And likewise, quite possibly this Selling Section of "Power" is not altogether complete, though it is the most complete power plant selling section in existence.

If it is not, we want to make it so.

We want to render it an absolutely unabridged guide and reference for anything to use about, around and in any way touching the power plant.

Therefore, we are going to do just what the libraries often do when they call on their readers to name books they think ought to be on the shelves.

And we ask this question:-

Is there anything you use, or have used and are likely to use again about your plant, that is not advertised in "Power"?

We do not refer to special brands of products as much as to kinds of products themselves, for of course there may be things you used many years ago which are no longer manufactured. You can refer to particular brands if you wish, but you can be sure if you tell us of any kind of product you use or want to use which we don't advertise, that we will get the best brand or brands of it made, into this Selling Section.

We're always talking about the way we can help you. Now here's a way you, the "Power" reader, can co-operate with us to help us, just as you did a little while ago in the collection of opinions on the various "Power" advertisements. This help from you will be a help to the other "Power" readers —and to those who will read "Power" in the future.

So, do this—

Look through the selling section from first page to last, and think. Then, if you note anything you believe ought to be there, which isn't, which can be of use anywhere in the power plant, tell us about it—please.

NEW EQUIPMENT

ATLANTIC COAST STATES

Bids will be received by M. C. Flagg, chairman of the light committee, Boylston Center, Mass., until June 20 for the construction of an electric light plant.

Chicopee, Mass., has voted bonds to the amount of $91,000 for the installation of additional electrical equipment in the municipal electric-light plant.

Princeton, Mass., is considering the installation of a municipal electric-light and power plant.

The construction of a power plant in connection with its establishment, at Warren, R. I., is contemplated by the Cutler Mills Corporation.

Bids are being received by the Western New York & Pennsylvania Traction Co. for the installation of a new power plant at Olean, N. Y. Estimated cost, $25,000. T. J. Miller is general manager.

The Sodus Gas & Electric Co. contemplates the construction of an electric-light plant at Ontario, N. Y. G. R. Mills, Sodus, N. Y., is general manager.

Bids will be received until 8:30 p.m., June 25, for the construction of a water-works system at Stanhope, N. J. Estimated cost, $30,000. Havens & Wood are consulting engineers.

C. B. Baker, construction quartermaster, U. S. A., will receive bids until June 15, for the installation of new boilers and the reconstruction of the electric-light plant at 26th street and Gray's Ferry Road, Philadelphia, Penn.

The citizens of Bridgewater, Va., contemplate the construction of a water-works system at a cost of $25,000.

SOUTHERN STATES

Plans are being prepared by J. N. Johnson, Florence, S. C., for the construction of a water-works system at Blackville, S. C.

The citizens of Blackshear, Ga., are considering a bond issue of $10,000 for the construction of a municipal electric-light plant.

Cartersville, Ga., has voted bonds to the amount of $50,000 for improving the water-works system and other work. G. W. Young is mayor.

The citizens of Jackson, Ga., have decided to improve the municipal water-works system. W. E. Merck is superintendent of the water-works.

The Wauchula Mfg. Co., Wauchula, Fla., will install an electric-light plant in connection with its new establishment.

The installation of a new power plant in Berea College, Berea, Ky., is under consideration. The plant will generate power for heating and lighting purposes.

The Henry Vogt Machine Co., Louisville, Ky., contemplates the construction of an addition to its power plant. The new addition will add about 300 kw. to the capacity of the plant.

CENTRAL STATES

Bonds to the amount of $140,000 have been voted for improving the water-works system at Alliance, Ohio. Plans have been prepared by Chester & Fleming, Union Trust Building, Pittsburgh, Penn.

Plans are in progress for the extension and improvement of the water-works system at Canal Dover, Ohio.

The Plain Dealer Publishing Co., Cleveland, Ohio, contemplates the enlargement of its power plant.

The Lake Shore Electric Co. contemplates the installation of new equipment in its power plant at Cleveland, Ohio. F. W. Coen, Sandusky, Ohio, is general manager and purchasing agent.

Bids will be received by W. E. Haswell, secretary, Ohio board of administration, until June 26, for furnishing generator sets at the Columbus State Hospital, Columbus, Ohio.

Niles, Ohio, has decided to extend and improve the water-works system. Charles A. Tompkins is president of the city council.

A bond issue of $60,000 has been authorized by the city council for the construction of a municipal electric-light plant at Wellsville, Ohio.

Bids will be received until July 10, for furnishing electrical equipment to be installed in the municipal electric-light plant at Kendallville, Ind. F. H. Froelich, Nasby Building, Toledo, Ohio, is consulting engineer.

The proposition to vote a bond issue of $49,500 for the improvement of the water-works system at Highland Park, Mich., is being considered by the citizens.

The Public Service Commission of Northern Illinois is considering the construction of an addition to its power plant at Waukegan, Ill. J. M. Strasser, Streator, Ill., is superintendent.

WEST OF THE MISSISSIPPI

The Citizens Gas & Electric Co. contemplates the construction of two substations in Waterloo, Iowa. William B. Addy, Waterloo, is manager.

James P. Porteus has received a franchise to construct and operate an electric-light plant at Leseur Center, Minn.

Newton, Kan., will install a water-works system to cost approximately $25,000.

The electric-light plant at Valley Falls, Kan., has been purchased by W. A. Spencer, of Holton, Kan., and considerable improvements are planned by the new owner.

The water plant at Omaha, Neb., will be bought by the city and considerable improvements are planned.

Hatton, N. D., will install new additional equipment in its power plant.

The construction of an electric-light plant at Mayville, N. D., is under consideration.

Bids will be received by the city council of McClusky, N. D., until June 20, for the installation of a water system.

Northwood, N. D., has voted bonds to the amount of $8,000 for the construction of an electric system.

Bids will be received by the city council, Torrington, Wyo., until June 28, for the construction of a water-works system. Plans have been prepared by the Shepperd Engineering Co., Majestic Building, Denver, Colo. Charles D. Brubaker is city clerk.

The citizens of Bethany, Mo., have voted bonds to the amount of $25,000 for the construction of a municipal electric-light plant. J. B. McClure is city clerk.

An expenditure of $100,000 is contemplated by the St. Joseph Street Railway Co. for additions and improvements to its power plant on Felix Street, St. Joseph, Mo. J. H. Van Brunt, St. Joseph, is general manager.

The National Enameling & Stamping Co., St. Louis, Mo., contemplates the installation of an electric-light plant in the new warehouse which is in the course of erection.

The plant of the Eldorado Light & Water Co., Eldorado, Ark., was recently destroyed by fire. Estimated loss, $25,000.

BUSINESS ITEMS

The Dearborn Drug & Chemical Works have removed their Indianapolis office to 919 Hume Mansur building. J. F. McDonnell has succeeded Mr. Clark, as manager of that office, Mr. Clark resigning June 1, to take charge of the Acme Engineering Company.

The Buckeye Boiler Skimmer Co., 519 Colburn St., Toledo, Ohio, manufacturers of the Buckeye boiler skimmer, received the following letter from Harold A. Keith, drainage contractor and civil engineer, Goshen, Indiana: "Accept my appreciation for your patience during the test of this skimmer. In explanation will say that when operation was commenced I had considerable difficulty in getting off the high ground and had to wait for water (rainfall). For the next period of time, covering four weeks, had only very little water which was being continually churned over. Will say I am fully satisfied with the help of the skimmer and feel that I cannot say enough for it."

ENGINEERS WANTED

Under this head are published, without charge, advertisements of actual vacancies in power plants for operating engineers and assistant engineers. For the guidance of applicants for advertised positions, the advertisements must contain particulars to show the class of service demanded and the wages paid. Employers who desire to advertise under this head are requested to write for a blank form of application.

HELP WANTED

Advertisements under this head are inserted for 25 cents per line. About seven words make a line.

SALES AGENTS to sell Goetze Metallic Packings of good reputation. Write us. Goetze Gasket & Packing Co., New Brunswick, N. J.

SALESMAN, having had experience in handling Mill Supplies, also good missionary man on Steam Specialties. Apply giving experience, references, and salary. The Fairbanks Company, Buffalo, N.Y.

SALES MANAGER. A prominent manufacturer of power specialties desires to secure the services of an experienced Sales Manager, capable of taking entire charge of the Sales Department. Must have a good general Engineering knowledge of power plant design and operation, acquainted with the jobbing trade and how to handle it, as well as having had experience in writing advertisements. Applicants will state age, education, experience in detail and salary expected. Address 676 Power.

MINE ELECTRICIAN for W. Va. coal camps, must have had practical experience, repairing mine locomotives and generators in coal camps. Ten locomotives, five generators, five motors, five mining machines. Give age, experience, where obtained, in what capacity, education and where obtained, married or single, salary expected. Only sober, practical men willing to live in coal camp need apply. Address 680, Power.

SALESMAN—Thoroughly competent steam specialty salesman; one that can sell high-grade goods. Address "M. M. Co.," Power.

STOKER ERECTORS, first class; none but experienced men need apply; state age, salary wanted, habits and references. Box 668, Power.

THE VULCAN SOOT CLEANER offers an exceptional opportunity for power specialty salesman. Address G. L. Simonds & Co., 802 Steinway Bldg., Chicago, Ill.

AGENTS WANTED to sell forced draft blowers and damper regulators; will give exclusive territory to right parties; commission on sales. Turbo-Blower Co., 30 Church St., New York.

AGENTS selling to steam plants can make big money selling for us; no samples; no experience is necessary. Armstrong Mfg. Co., Springfield, Ohio.

MANUFACTURERS' AGENTS to handle thoroughly guaranteed steam specialties; feed water heaters, steam and oil separators, traps and exhaust pipe heads; not necessary to represent entire line if interested in only part of it; our specialties are well advertised and of good reputation. Box 569, Power.

SITUATIONS WANTED

Advertisements under this head are inserted for 25 cents per line. About seven words make a line.

STEEL CABLE SPLICER, desires position, United States preferred, 22 years' experience as engineer and steel cable splicer. References furnished. Box 683, Power.

CHIEF ENGINEER—Open for engagement; electric light and railway power stations, factory and institution steam plants; 40 years of age; well educated and good reputation. Box 682, Power.

TESTING ENGINEER, M.E., European and American experience, 12 years, open for engagement by large power company or manufacturing concern. Laboratory, boiler and engine tests, fuel analyses, economy researches. Best references. Box 679 Power.

CHIEF ENGINEER or Master Mechanic. Age 38, with 20 years of broad practical experience

installing and operating large gas, steam and electric power plants. Has 1st Class Mass. License and references as to character and ability. Box 681, Power.

STEAM ENGINEER, age 27, technical student. High speed engines, steam pumps, centrifugal pumps, desires a position where he can get experience with electric machinery. Adon Seager, Denmark, Ia.

MISCELLANEOUS

Advertisements under this head are inserted for 25 cents per line. About seven words make a line.

PATENTS SECURED—C. L. Parker, Patents, 904 G St., Washington, D. C.

EVERY ENGINEER should be posted regarding the new system of vacuum heating installed without payment of royalty; I have valuable information; write today. M. Y. C., 1417 W. Jackson Blvd., Chicago, Ill.

TREASURY DEPARTMENT—Office of the Supervising Architect, Washington, D. C., June 7, 1912. Sealed Proposals will be received at this office until 3 o'clock p. m. on the 21st day of June, 1912, and then opened, for supplying to the various public buildings under the control of the Treasury Department, lubricating oils, during the fiscal year ending June 30, 1913, in accordance with the specification, copies of which may be had at this office at the discretion of the Supervising Architect. James Knox Taylor, Supervising Architect.

FOR SALE

Advertisements under this head are inserted for 25 cents per line. About seven words make a line.

1-225 H.P. NORDBERG Cross Compound Condensing Corliss Engine, 12x22x36; 14 ft. rope pulley; 10 grooves 1¼" rope; 1-125 K.W. 2 phase, 60 cycle, 2200 volt Westinghouse generator, with exciter, and switchboard panel; the unit is immediately available as being taken out to make room for a 1000 K.W. steam turbine. For further particulars address, Board of Public Works, Holland, Mich.

FRANKLIN WATER TUBE BOILER, 182 hp., used three weeks. Franklin Boiler Works Co., Troy, N. Y.

ONE 120-kw. a.-c., 440-volt Westinghouse generator. One 16x42 Allis Corliss engine, complete with all fittings, including exciter and switchboard. Address "Engineer," Box 2, Station A, Cincinnati, Ohio.

350 KW. WESTINGHOUSE direct current generator, 250 volts, direct connected to 24x36 heavy duty Corliss engine; unit complete with switchboard, balancing set, etc. Arthur S. Partridge, 417 Pine St., St. Louis.

CORLISS ENGINES: 5000 hp. Allis vertical cross compound Corliss; 1200 hp. Hamilton horizontal cross compound Corliss; 750 hp. Filer & Stowell cross compound horizontal heavy duty with condenser. Arthur S. Partridge, 417 Pine St., St. Louis.

500 HORSEPOWER right-hand engine; simple Corliss heavy duty frame, size, 24x48, complete, including flywheel, 18 ft. diameter, grooved for 14 turns 1¼-in. rope, American drive-steam receiver separator, 7-in. steam pipe including one long radius bend and flanges; can be seen in operation at our mill in Mt. Carmel, Ill. Address Bernet Craft & Kauffman Mlg. Co., Office 1036 Pierce Building, St. Louis, Mo.

ONE HEWES & PHILLIPS Corliss engine, 14x36 in., in excellent condition; flywheel, 10 feet diameter, 18 in. face, five to six years old. One 75-kw. a.c. Westinghouse generator, 3 phase, 220 volts, 60 cycles, 900 r.p.m. with switchboard and exciter complete. One 50-kw. a.c. Westinghouse generator, 3 phase. 220 volts, 60 cycles, 1200 r.p.m. with switchboard and exciter complete. One 45-kw. d.c. General Electric generator, 115 volts, 850 r.p.m., with switchboard complete. The Salt's Textile Mfg. Co., Bridgeport, Conn.

100 HP. SCOTCH MARINE BOILER, 18 months old, 125 lbs. Hartford insurance, butt-strapped, triple riveted, $500 f.o.b. Sunbury, Ohio. Duzets & Son, 50 Church St., N. Y.

Two (2) 72 in. x 14 ft. return Tubular Boilers (103 3½" Tubes each) working pressure 110 lbs. and 90 lbs. respectively complete with plate steel fronts and cast iron trimmings, one (1) Westinghouse Compound Engine (Cylinders 8x13x8), direct connected with a d.c., 25-kw., 125 volts General Electric Generator including one (1) 200 Ampere Meter, Circuit Breaker and Rheostat. Reason for selling, larger installation. For price and information, write McCormick & Co., 105 Concord St., Baltimore, Md.

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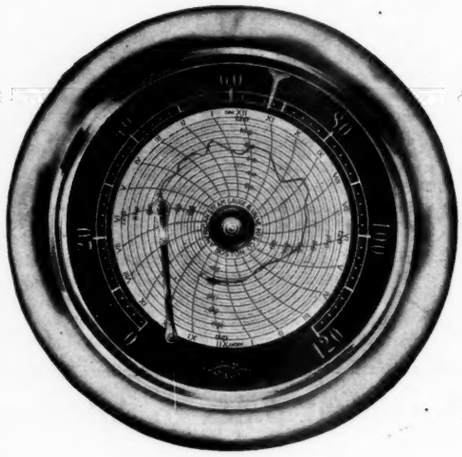

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